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CONGRATULATIONS

It is with great pleasure and pride that the ISOR congratulates Dr. R.S. Paroda, on his being conferred the title ***PADMA BHUSAN****. Dr. Paroda is presently a life member of this society. He was president of ISOR for two consecutive terms during 1990-91 and 1992-93. During his Presidentship, the ISOR organised the II National Seminar on Oilseeds with the theme* ***Sustainability of Oilseeds Production*** *which discussed the various issues of increased oilseeds production and self sufficiency inculding export prospects. Due to the efforts of leaders like him India is on top today in the production and export of some oilseeds in the world. Dr. Paroda also has rendered yeoman service in increasing the agricultural production in general and conserving genetic resources of various crop plants in particular. Through exemplarly leadership qualities and vision he has put Indian Agriculture on top in the world. We salute and once again congratulate him on receiving the Padma Bhusan award.*

G. Nagaraj

Editor

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RAPESEED - MUSTARD BASED INTERCROPPING SYSTEMS - A CRITICAL REVIEW

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ABSTRACT

Keeping in view the non-availability of land for further expansion of area under oilseeds, the increasing gap between demand and supply of vegetable oils in the country can be bridged by increasing their production per unit area per unit time. Total production of rapeseed-mustard vis-a-vis oilseeds can be increased by intercropping them with compatible crops. Their intercropping with crops such as sugarcane, chickpea, lentil, potato, wheat, barley has been found successful under different agroclimatic situations of the country. It is observed that higher yields of mustard can be achieved without significant reductions in yield of main crops, thus, leading to higher income from intercropping systems. Sowing of one row of rapeseed-mustard, between normal planted rows of sugarcane, or after 2,3 or 4 of chickpea, after 1 or 2 row of lentil, after 2 or 3 rows of potato, after 6, 8, 10 rows of wheat or barley or raising 4 rows of rapeseed-mustard after 12 rows of wheat or intercropping of Indian rape and Swede rape in alternate rows at 22.5 cm apart have been found more remunerative at different locations. Intercropping of mustard with sugarcane, potato, chickpea or lentil did not require any additional fertiliser whereas Indian rape - Swede rape intercropping required 150 kg N and 30 kg P_2O_5/ha. Variety Varuna was found to be the most compatible for intercropping with sugarcane, chickpea, potato and wheat. Weeds can be effectively controlled by application of Isoproturon, fluchloralin or trifluralin in Indian rape + Swede rape, by fluchloralin and pendimethalin in chickpea + mustard and by isoproturon in wheat + mustard intercropping systems. The possible mechanisms leading to compatibility of component crops in different intercropping systems have been discussed, in the light of available information.

Key Words : *Intercropping, rapeseed-mustard, yield, monetary returns.*

INTRODUCTION

Oilseeds constitute an important group of crops next only to cereals. Besides being a rich source of edible oil and cooking media, these serve as an important raw material for various industrial products. Oilseeds are sources of energy, essential fatty acids and fat soluble vitamins. India is the third largest producer of oilseeds in the world. These oilseed crops comprise groundnut, rapeseed-mustard, soybean, sunflower safflower, sesame and niger among edible; linseed and castor among non-edible and coconut and oil palm among tree oilseed crops. Nearly 90 per cent of the total vegetable oil produced in the country is derived from groundnut and rapeseed-mustard. Rapeseed-mustard alone occupies one-fourth of the total area and account for an equivalent amount of total oilseeds (Paroda, 1992). At the global level, this country producing one-fifth of the world's rapeseed-mustard ranks second, next only to Canada (Deoghare and Agrawal, 1994).

Rapeseed-mustard comprise three sub-species of *Brassica campestris* namely Toria, yellow sarson and brown sarson (referred to as Indian rape), raya/rai/Indian mustard (*Brassica juncea* (Linn)) referred as mustard, *Brassica napus* as Gobhi sarson or Swede rape, *Brassica carinata* as Ethiopian mustard, *Brassica nigra* as black mustard and *Eruca sativa* as taramira. Swede rape and Ethiopian mustard are recent introductions to India. While Swede rape cultivation is confined only to irrigated areas;

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Ethiopian mustard is better adapted to rainfed conditions. Among rapeseed-mustard the major share is of Indian rape and mustard which are mainly confined to Northern parts of the country with Uttar Pradesh and Rajasthan together sharing about 50 per cent of the total area under rapeseed-mustard. About 80 per cent of the total area under oilseeds is unirrigated. However, only about 46 per cent of the total area under Indian rape and mustard is unirrigated and in North western parts of the country, the irrigated areas under rapeseed-mustard range between 47-91 per cent (Sahota and Saini, 1989).

Although, the country has achieved great strides in production of cereals, the low level of production and productivity of oilseeds is a matter of great concern. Estimates of demand-supply proposition indicate that 24.3 million tonnes of edible oilseeds would be required by the turn of the century against the present production of 21.3 million tonnes (Prasad, 1994). There is little scope to bring additional area under oilseeds due to stiff competition from cereals, shrinkage of land holdings and use of land for urbanisation, industrialisation etc. Thus, in the absence of possibilities for horizontal expansion, the vertical growth of these crops through intercropping with other crops offering varying competition in space and time is the need of the time.

Advantages of Intercropping

Mixed cropping or intercropping is an age old practice. Though, these two terms can be distinguished on row arrangement basis, yet it is difficult to make distinction between them while reviewing literature as these have been used quite synonymously. The terminology related to these systems have been dealt in detail by Willey (1979) and Pal *et al.* (1985). Mixed cropping in which seeds of different crops are mixed together in different proportions and broadcast is, however, subsistence oriented low yield technology primarily based on the principles of survival of crops even under suboptimal environmental conditions.

The present day intercropping is production oriented and requires a fairly good level of management and inputs. The growth resources are better utilised by replacing some of the rows of main crop or by modifying the inter-row spacing. Intercropping provides greater stability of yield and income. Such advantages are more under poor growing conditions (Willey, 1981; Austain and Morris, 1985; Gupta and Singh, 1988). The yield advantages under intercropping are mainly due to improved productive utilisation of photosynthetically active radiation, improved water use efficiency and nutrient recycling (Rao and Willey, 1980; Mandal *et al.* 1986; Batra *et al.* 1987; Mandal and Mahapatra, 1990; Mandal *et al.* 1991) diversification, maintenance of soil fertility, spreading labour peaks (Sidhu *et al.* 1988) and better weed control (Sengupta *et al.* 1985). Intercropping help to reduce the risks at times of adversity and is regarded as safe insurance against total loss. Salter *et al.*, (1985) focussed on the advantages of intercropping under mechanised farming.

Intercropping of Rapeseed-mustard

Several studies on intercropping of different crops have been reviewed by many workers (Narwal and Malik, 1981; 1981a, 1981b; Chatterjee and Mandal, 1992). Sahota and Saini (1989) reviewed the research work on different agronomic aspects of rapeseed-mustard. Rapeseed-mustard can be intercropped with large number of crops such as wheat, chickpea, potato, sugarcane, barley, lentil, linseed, winter maize etc. Hegde and Pandey (1992) and Hegde (1993) summarised the work done under the aegis of All India Coordinated Project on Cropping Systems Research. Here an attempt has been made to critically review the research work done on different agronomic aspects of intercroppping systems (ICS) of

rapeseed-mustard with reference to mechanism **and behaviour of component** crops under ICS.

Sugarcane + mustard

Autumn planting of sugarcane (mostly CoJ 64 and CoS 767) is prevalent in Northern India due to favourable climatic conditions for germination and growth. Singh and Gupta (1981) reported that autumn planted sugarcane yielded about 20 per cent more cane and 0.5 per cent more sugar recovery than spring planted crop. Loss of *rabi* crop due to autumn planting of sugarcane can be compensated through intercropping in sugarcane (Narwal and Malik, 1981). These intercrops provide protection to sugarcane from frost. Kumar (1983) and Shivay *et al.* (1996) suggested inclusion of Varuna variety of mustard in Sugarcane + mustard ICS.

In most of the studies, reduction in yield of sugarcane intercropped with other crops was observed compared to cane alone. Kanwar *et al.* (1988) reported significant reduction in tiller number and cane yield in sugracane (CoJ 64/ CoJ 65) + mustard (RLM 514) ICS as compared to cane alone. Singh *et al.* (1996) also reported reduction in yield of autumn planted sugarcane when intercropped with mustard. Likewise yield of mustard was lower in ICS than its sole crop.

On the contrary, Singh *et al.*, (1985) observed no reduction in cane yield at Barabanki whereas Rathi and Singh (1979) reported an increase of about 13 per cent in cane yield at Kanpur in cane + mustard ICS over pure crop of sugarcane. Intercropping of mustard with autumn planted sugarcane gave additional yield of 1.5 t/ ha of mustard without any reduction in sugarcane yield (Singh *et al.*, 1985). Land equivalent ratio (LER) of such an ICS was 52-60 per cent higher over sole crops (Singh *et al.*, 1986). Similarly, additional yield of 2.83 q/ha of mustard at Pantnagar (Kumar, 1983) and 10-16 per cent at Kanpur (Rathi, 1980) was obtained compared to pure crop of mustard. Intercropping of mustard with sugarcane was more remunerative than sugarcane alone (Dixit and Mishra, 1991; Gulati *et al.* 1995; Shivay and Rathi, 1996).

The success of mustard intercropped with sugarcane can be ascribed to better complementary use of growth resources in both *space and time. Wider row spacing and slow* initial growth of sugarcane offers little competition to mustard. Misra (1989) observed that dissemination of smut (*Ustilago scitaminea* Mundker) spores was interrupted when mustard was intercropped between healthy and diseased rows of sugarcane due to reduced air turbulence.

However, growing of intercrops in between cane rows causes shade to the base of sugarcane plants from where tillers emerge. Tiller production is hampered and hence dry matter accumulation is greatly reduced. Therefore short duration varieties of companion crops which vacate the field much earlier than the tillering phase of sugarcane caused little adverse effect of sugarcane.

Chieckpea + mustard

Intercropping of chickpea and mustard has proved to be a potentially beneficial system under irrigated as well as rainfed conditions (Kushwaha and De, 1987; Cheema and Sahota, 1987; Ali, 1988). Parkash (1992) observed that chickpea + mustard ICS was more rewarding than wheat + mustard ICS.

Intercropping of chickpea (C-235) with mustard (Varuna) significantly reduced the dry matter (DM) per plant of chickpea in all the row ratios except 9 : 1 spatial ratio (Patel *et al.* 1991). *Meena (1989). Ali (1992) and Mandal et al.*, (1994) also reported similar findings. Ali (1992) registered maximum DM production of chickpea at 120 DAS and that of mustard at 90 DAS in 4 : 1 row proportion of chickpea + mustard (Fig.I) which declined afterwards due to senescence of leaves. The maximum DM accumulation registered in ICS by mustard was higher and that of chickpea was lower than their respective sole crops in 4 : planting pattern. The DM accumulation by chickpea was greater when intercropped with yellow sarson in 1 : 2 than in 1 : 1 row ratio (Mandal *et al.* 1994). Leaf area of chickpea decreased in mustard + chickpea ICS (Meena, 1989). LAI of chickpea was drastically reduced while number of nodules per plant and weight of viable nodules of chickpea were increased in chickpea + mustard ICS under rainfed conditions compared to sole crop of chickpea (Kushwaha and De, 1987). Taller plants of chickpea and mustard were recorded in 2 : 2 and 3 : 1 row ratio, respectively in chickpea + mustard ICS (Sachan and Uttam, 1992) Fig-1.

Reduction in yield attributes and seed yield of chickpea was minimum in wider (8 : 1 or 9 : 1) compared with narrow row ratios of chickpea + mustard (Gangasaran and Giri, 1985; Patel *et al.* 1991; Singh and Yadav, 1992). Better yields in wider spatial pattern of ICS were also reported by many workers (Singh, 1981; Tarkalkar and Rao, 1981; Waghamare *et al.* 1982). Significantly more number of pods per plant, grains per pod and grain weight per plant of chickpea were recorded with 2 : 2 row ratio compared with 2 : 1 and 3 : 1 row ratio, whereas seed yield of chickpea was greater in 3 : 1 row ratio of chickpea + mustard ICS. However, yield of sole crop of chickpea was the maximum (Sachan and Uttam, 1992). Similar reductions in yield attributes and seed yield of chickpea in the ICS over sole crop of chickpea have been reported from various locations (Mehta and De, 1980; Kumar and Singh, 1987; Kushwaha and de, 1987; Keshwa *et al.* 1988; Singh *et al.* 1988; Meena, 1989; Ali 1992; Singh and Yadav, 1992; Vyas and Rai, 1993; Upasani, 1994). Paired planting of chickpea alone produced more chickpea equivalent yield (26.0 q/ha) than paired planting of chickpea one row mustard, intercropping of mustard (in normal rows) 45 cm apart of chickpea or in paired rows of chickpea at 30/60 cm. However, chickpea alone (23.0 q/ha) at 45 cm row spacing gave poor yield (Singh *et al.* 1988). Likewise chickpea + mustard (1:1 row ratio) sown 30 cm apart gave lower yield than chickpea alone (Upasani, 1994).

Patel *et al.*, (1991) obtained maximum seed yield of mustard with sole crop which decreased significantly with increase in chickpea rows in ICS. Studies have, however, revealed that reduction in mustard yield was not proportional to decrease in its plant population in the ICS (Kushwaha and De, 1987; Singh *et al.*, 1988; Gangasaran and Giri, 1985). Reduction in seed yield of mustard was minimum in 1 : 4 spatial arrangement in a wet year and in 1 : 6 row ratio of mustard + chickpea in dry year (Gangasaran and Giri, 1985). Sachan and Uttam (1992) reported maximum mustard yield in 2 : 2 (6.3 q/ha) followed by 2 : 1 (5.2 q/ha) and 3 : 1 (3.5 q/ha) planting pattern. Vyas and Rai (1993) reported that mustard + chickpea in 3 : 1 planting pattern resulted in higher yield of mustard (27.2 q/ha) compared to 4 : 4 row ratio (21.1 q/ha). At Jobner, highest seed yield of mustard was registered in 2 : 1 chickpea + mustard ICS (Keshwa *et al.* 1988).

Kushwaha and De (1987), Singh *et al.*, (1987) and Kushwaha (1992) registered higher yield of mustard when intercropped with chickpea compared to its sole crop yield. Similar instances of current, benefit to non-legume in association with legume have been reported elsewhere (Eaglesham *et al.* 1981; Waghmare *et al.* 1982).

The productivity of mustard + chickpea (1 : 4 or 1 : 3) ICS was higher than that from either of the component crops grown separately at Kanpur (Rathi, 1980). Singh (1981) observed that intercropping of Indian rape (*Brassica tornifortii*) with chickpea increased total yield by 41-70 per cent compared to sole crop of chickpea, whereas Singh *et al.*, (1987) corroborated that paired planting of mustard (30/90 cm) + 2 rows of chickpea gave 19.1 q/ha of mustard with

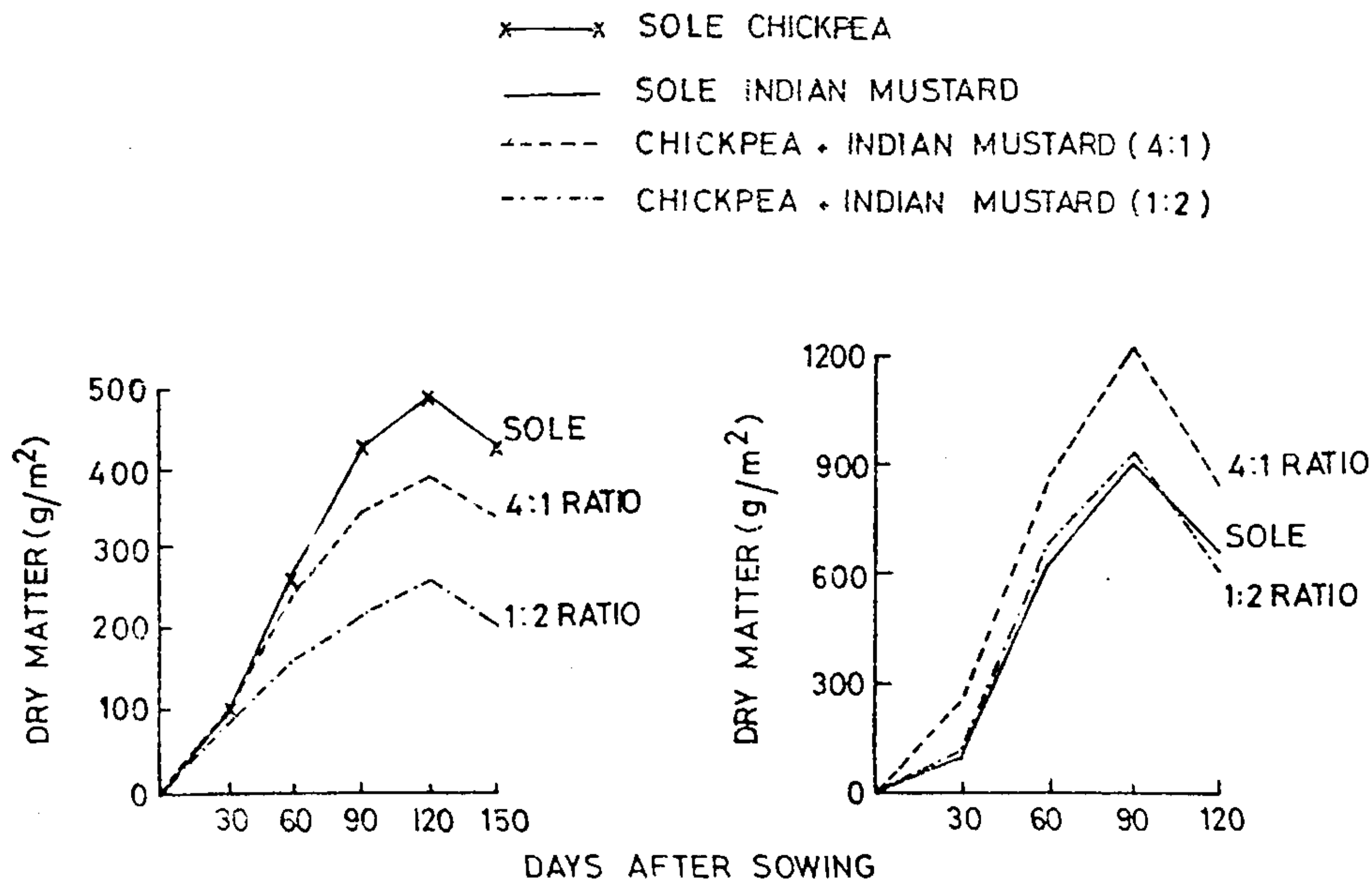

Fig 1. Pattern of dry matter accumulation of chickpea and India mustard under sole and intercropping system
Source : Ali, M. 1992 Indian Journal of Agronomy. 62: 249 - 253

additional 10.6 q/ha of chickpea. Similar yield advantages in chickpea + mustard in 3:1 or 4:1 planting pattern or paired planting of chickpea + one row of mustard over sole crops have been demonstrated (AICORPO, 1987-88; Ali, 1992; Singh and Yadav, 1992). Intercropping system comprising 2/3 mustard + 1/3 chickpea also gave maximum total mustard equivalent yield (Kushwaha and De, 1987).

Intercropping one row of mustard after every 5 or 6 rows of chickpea was more remunerative at Durgapur and Jhunjhunu districts of Rajasthan and Rohtak and Jind districts of Haryana (Choudhury, 1991). Net returns from chickpea + mustard ICS in different row proportions were higher than their sole crops at most of the locations (Kumar and Singh, 1987; Singh *et al.* 1988; Verma *et al.* 1989; Mehta *et al.* 1990; Bhola *et al.* 1991; Patel *et al.* 1991; Sachan and Uttam, 1992; Singh and Yadav; 1992; Hegde Pandey 1992).

The maximum net returns in chickpea + mustard ICS over sole chickpea were obtained in paired row of chickpea (30/60 cm) + one row of mustard at Hisar (Mehta *et al.* 1990), 2:1 row ratio at Pantnagar and Kanpur (Bhola *et al.* 1991), 2:2 paired planting at Ludhiana (Hegde and Pandey, 1992) and 8:1 row ratio at Faizabad (Singh and Yadav, 1992). Similar advantages over sole mustard crop were registered in 3:1 at Kanpur, Durgapur, Hisar, Pantnagar, 1987; and Udaipur (AICORPO, 1985-86, Kumar and Singh, 1987; Patel *et al.* 1991), 4:1 at Kanpur (Verma *et al.* 1989) 2:2 paired planting at Varanasi (Singh *et al.* 1987) and 5:1 row ratio of chickpea + mustard ICS (Choudhury, 1991).

The additional benefits from chickpea + mustard (6:1) ICS ranged between Rs.600/ha in Rajasthan to Rs.2200/ha in Haryana (Hedge, 1993). Verma and Srivastava (1987) and Keshwa *et al.*, (1988) obtained the maximum net returns in 3:1 and 2:1 planting pattern of chickpea + mustard, respectively.

Awrodhi cv. of chickpea showed better performance than cv. K-468 when intercropped with mustard variety Varuna at Kanpur (Sachan and Uttam, 1992). Ali (1992) also from Kanpur reported better performance of PDG 84-16 than TM-4 when intercropped with chickpea at Jobner.

Nitrogen removal from soil by chickpea decreased while that of mustard increased with increase in proportion of mustard in ICS (Kushwaha, 1983; Kushwaha and De, 1987). In terms of mustard seed equivalent yield the response was only upto 10 kg phosphorus per ha in chickpea + mustard ICS. The P uptake was significantly higher in sole stand of mustard and 1:3 row ratio over 4:4 row ratio (Vuas and Rai, 1993). However, Meena (1989) observed that P and K content of component crops were not affected in ICS.

Indian rape (B-9) and chickpea (B-115) in 2:1 row proportion recorded higher combined root dry weight over chickpea alone and higher consumptive use of water over both the sole crops indicating better complementarily of component crops (Mandal *et al.* 1994). Irrigation improved growth, yield attributes and water use efficiency of component crops; however yield differences were not significant due to one or two irrigations (Singh *et al.* 1987). Kushwaha and De (1987) reported that mustard alone depleted more soil moisture than when intercropped with chickpea in 1/3 mustard (Pusa Kranti) + 2/3 chickpea (BG-203) ICS.

Yield losses caused by weeds in component crops ranged from 44-70 per cent in the ICS. Effective control of weeds and higher yield of chickpea and mustard in chickpea + mustard ICS were obtained with application of fluchloralin and pendimethalin, respectively with each applied as pre-emergence @ 1.0 litre per ha (Panwar *et al.* 1987).

Success of component crops grown in association depends upon their relative growth pattern and degree of competition offered by one over the other, although the competitive ratios of chickpea + mustard ICS have indicated that mustard was more competitive than chickpea (Kushwaha and De, 1987; Mehta *et al.* 1990), the ICS was more rewarding than pure crops. Yield advantages in ICS are mainly due to large differences in growth pattern of component crops leading to complementary use of growth resources. Balanced equilibria determined by relative growth of associated crops, large differences in rooting pattern leading to moisture extraction from different layers (Kushwaha and De, 1987), reduced evaporation and stress due to complete coverage of surface (Sheldrake and Saxena, 1979; Natrajan and Willey, 1980) and the fact that their peak demand for water do not coincide with each other (Singh *et al.*; 1987), increased availability of nutrients particularly N and P due to differences in rooting pattern and current transfer of nitrogen from chickpea (due to its ability to fix atmospheric nitrogen) to mustard, degeneration of chickpea nodules, solubilisation of soil phosphorus, improved soil physical characteristics (Kushwaha and De, 1987; Dhillon and Vig, 1985) and reduced severity of blight disease to chickpea (Singh and Yadav, 1992) are the major factors leading to success of chickpea + mustard ICS.

Indian rape/mustard + lentil

Intercropping of mustard with lentil was more profitable than sole crops at Kanpur (Kushwaha, 1985), Sangrur (Hegde, 1993) and Bahraich (Singh and Rajput, 1996).

The lentil yield was higher in 6:1 row ratio than 4:1 row ratio lentil whereas reverse was true for mustard yield. However, maximum lentil equivalent yield and net profits were obtained with 6:1 row proportion of lentil (PL-406) + mustard (Kranti) ICS (Singh and Rajput, 1996). At Mohanpur, West Bengal, Indian rape + lentil in 1:1 row proportion gave higher net returns than that of 1:2 or 2:1 row proportion (Mandal *et al.* 1996).

Indian rape + lentil in 1:1 row ratio was more rewarding than both the sole crops (Kumar and Singh, 1983; AICORPO, 1987-88, Kumar *et al.* 1994) while 1:3 spatial ratio was more remunerative over Indian rape only (AICORPO, 1985-88), Yield of Indian rape in Indian rape + lentil ICS was either lower or equal to its sole crop yield at different locations (AICORPO, 1984-85). However, Indian rape equivalent yield in Indian rape + lentil or Indian rape + linseed was more than their pure crop yields and Indian rape + lentil was more remunerative than Indian rape + linseed (AICORPO, 1984-85). However, at New Delhi, LER of mustard + lentil ICS was less than 1.0 indicating that mustard was competitive to lentil (Gangasaran and Giri, 1985). among different varieties of mustard, Kranti proved the best when intercropped with lentil (Singh and Rajput, 1996).

The maximum yield of mustard (18.0 q/ha) obtained with 40Kg N + 40 Kg P_2O_5/ha was equal to that obtained with 40Kg N + 40 Kg P_2O_5 + 40 Kg K_2O/ha (17.8 q/ha) in mustard + lentil ICS or that of pure mustard (18.6 q/ha) applied 80 Kg N + 60 Kg P_2O_5/ha in soils low in N and medium in P and K at Kanpur (Kushwaha, 1985). Moisture extraction studies indicated that due to shallow rooted nature of Indian rafe and lentil, these•extracted maximum moisture upto 45 cm soil depth in Indian rape + lentil ICS (Mandal *et al.* 1994).

Potato + mustard

Because of dissimilar growth durations and canopy characteristices, potato and mustard can be grown in association. On highly erodible sandy loam soils of Agra, intercropping of potato + mustard in 2:1 proporation registered about 50 q/ha lower potato yield compared to its pure crop yield (Prakash, 1992). Rathi and Keim (1982), Singh and Rathi (1984) Singh and Verma (1989) and Rathi *et al.*, (1992) reported about 6-10 per cent reduction in tuber yield of potato in potato + mustard were 75 and 55 per cent, respectively of their pure crop yields (Gangasaran *et al.* 1994). Yield reductions in potato are due to reduced plant population and may also be due to teletoxic (allelopathic) effect of mustard on potato roots (Singh and Rathi, 1984). although the yield of main crop of potato decreased, the loss was more than compensated by the additional yield of mustard in ICS (Rathi and keim, 1982; Parakash, 1983; Rana and Singh, 1992; Parkash, 1992). Parkash (1983) and Singh (1985), Narwal and Prakash (1992) reported improvement in yield attributes per plant of mustard in potato + mustard ICS over its pure crop stand. Seed yields of mustard were 57, 56 and 46 per cent in 2:1, 3:1 and 4:1 row proportion, respectively in potato + mustard ICS (Gangasaran *et al.* 1994). Similarly yields of mustard in ICS were 66-75 per cent at Kanpur (Rathi and Keim, 1982) and 51 per cent at Faizabad (Singh and Verma, 1989) compared to its pure crop yield.

Intercropping of mustard or Swede rape with potato was found rewarding at many places (Rathi and Keim, 1982; Singh and Rathi, 1984; Rathi *et al.* 1982; Narwal and Parkash, 1992). Prakash (1992) reported maximum returns from 2:1 potato + mustard ICS over sole crop of potato at Agra whereas Gangasaran *et al.*, (1994) reported similar findings in New Delhi. Superiority of potato + mustard intercropping in 3:1 row proportion over pure crops was established at Pantnagar, Faizabad and Hisar (AICORPO. 1982-87; Parkash, 1983) and (Kanpur Rathi and Singh, 1983 Rathi *et al.*, 1992). Singh and Verma (1989) and Rana and Singh (1992) also reported better monetary returns from ICS compared to pure crops. Singh (1985) found that relay intercropping of rapeseed (one cut for fodder at 60 DAS) + potato followed by berseem was more remunerative than pue crop of potato. Narwal and Parkash (1989) at Hisar reported that intercropping of potato with Swede rape was more beneficial than with mustard. Rathi and Verma (1979), Kumar (1983), Yadav (1984), Rathi *et al.*, (1992) suggested inclusion of variety Varuna *than any other variety of mustard for its* intercropping with potato. Likewise for potato, short duration variety chandramukhi gave the bes performance (Rathi and Verma, 1979).

Mustard should receive first irrigation after earthing up of potato and subsequent irrigations to potato should be given after closing furrows from both the sides of ridge on which mustard is planted (Anonymous, 1983).

Singh and Rathi (1984) reported that maximum yield of component cros of potato and mustard were obtained with nitrogen application of 120 and 160 Kg/ha, respectively (Fig. 2). Rathi and Singh (1983), Singh and Rathi (1984) and Singh and Verma (1989) registered maximum yield of component crops and potato equivalent yield with 150 Kg N/ha. In the ICS, phosphorus content in shoot s of both potato and mustard improved, while potassium content of mustard decreased (Parkash, 1983; Singh, 1985). Application of 90 Kg P_2O_5/ha increased seed yield of mustard, tuber yield of potato and potato equivalent yield, whereas 80 Kg K_2O/ha improved the growth ad yield attributes of potato only in potato + mustard ICS (Rana and Singh, 1992).

Intercropping with potato improved the growth and yield attributes of mustard and Swede rape owing to complementary effect of component crops in temporal an spatial use of growth resources. Potato is a short statured, shallow rooted crop and can utilise fixed phosphorus from soil (Parkash, 1983; Singh, 1985) and thus offers little competition for growth resources to mustard/ Swede rape (Narwal and Parkash, 1992; Rathi *et al.*, 1992). Mustard is a relatively longer duration crop and can utilise the nutrients apple directly

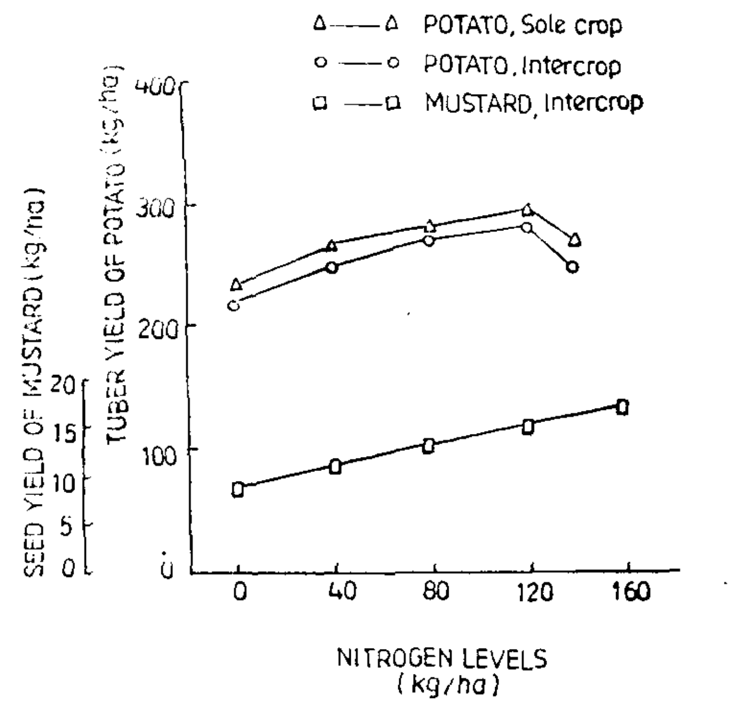

Fig 2. Tuber yield of Potato and seed yield of mustard in intercropping system as influenced by Nitrogen levels at Kanpur (Mean of 2 years, 1976-77 & 1977-78)
Source : Singh and Rathi, 1984

to potato and those mineralised after potato havest. Frequent interculture operations practised in potato pulverise the soil, improve soil aeration, lead to better control of weeds, ultimately leading to improved productivity of mustard. To minimise shade effect of mustard on potato, short duration variety such as Kufri chandramukhi of potat and longer duration variety like Varuna of mustard are highly compatible. One row of mustard sown after every three rows of potato leads to minimum shade effect.

Wheat + mustard

Of the total area under rapeseed-mustard, in the country, more than 60 per cent is grown as mixed or intercrop mostly in wheat (Parameswaran *et al.* 1988). Thus, it is the most pre dominan ICS. Considerable research work has been conducted on different agronomic aspects of this ICS and the findings have been recommended by many states of Northern India.

Kler and Atwal (1983) observed no market influence of row direction (N_S or E_W) on the wheat yield in wheat + mustard ICS. Batra *et al.*, (1987) at Hisar; Gupta and Singh (1989) at Jammu, Tomer *et al.* (1990) at Tikamgarh, Singh and Yadav (1990) at Kumarganj; Singh and Gupta (1992) at Pantnagar and DAs *et al.*, (1992) at Jorhat reported reduction in yield of wheat in ICS compared to sole crop of wheat. It is suggested that to have minimum reduction in wheat yield and to obtain mustard yield as a bonus, one or two rows of mustard should be sown after 10 or 11 rows of wheat (Sharma *et al.* 1986; Tomer *et al.* 1990; Hegde and Pandey, 1992; Dutta *et al.* 1994). Kler and Atwal (1983) reported similar results in 12:1 row proportion of wheat + mustard ICS at Ludhiana. Seed yields of mustard depending upon its proportion in the ICS with wheat also deceased compared to its pure evcrop yeild (Singh and Yadav, 1990; Singh and Gupta, 1992; Singh *et al.* 1992). The yield of mustard was the highest in 2:1 row proportion of wheat + mustard ICS over other spatial ratios at Hisar (Batra *et al.* 1987), Rewa (Dwivedi and Namdeo, 1992) and Jorhat (Dutta *et al.* 1994). Sharma *et al.*, (1986) and Singh *et al.*, (1992) observed that mustard yield was more when sown mixed with wheat compared to its intercropping with wheat.

One row of mustard after every ninth row of wheat was the appropriate method of intercropping in Rajasthan and eastern U.P. (Parameswaran *et al.* 1988) and Panjab (Cheema and Sahota, 1987). Mustard + wheat in 2:10 row proportion was found appropriate under irrigated conditions of Pantnagar, Navsari, rohtak, Sirsa and Jind, whereas wheat + muistard in alternate rows was found better at Kalyani and Varanasi (Hegde and Pandey, 1992; Hegde, 1993). However kler andAtwal (1983), Sharma *et al.*, (1986) and Tomer *et al.*, (1990) registered maximum wheat equivalent yield with 6:1, 3:1 and 3:1 wheat + mustard spatial ratio, respectively. Das *et al.*, (1992) reported higher yields from wheat + Swede rape than wheat +mustard ICS.

Intercropping of wheat + mustard was found to be more profitable over main crop or both the component crops at almost all the locations and the returns varied depending upon the crop geometry and prevailing market prices of component crops during different years. Net profit from wheat + mustard (7:1) ICS was more as compared to wheat alone at Agra (Singh and Agarwal, 1990). the maximum gross returns were recorded in 6:1 row ratio of wheat + mustard at Ludhiane (Kler and Atwal, 1983), 6:2 row ratio at Pantnagar (Singh and Gupta, 1992) and parts of Haryana (Hegde, 1993), Similarly maximum net returns were obtained in wheat + mustard ICS of 3:1 at Tikamgarh (Tomer *et al.* 1990), 2:1at Rewa (Dwivedi and Namdeo, 1992) and Kumarganj (Singh and Yadav, 1994). However, wheat + mustard in 12:4 row ratio gave maximum profit at Ludhiana (Sawhney *et al.* 1983). Intercropping increased the profit by 7-8 per cent at kalyani and Pantnagar (Hegde and Pandey, 1992). Similarly work done under the aegis of All India Coordinated Project on oilseeds revealed the intercropping increased the net returns over mixed sowing of wheat + mustard and also ove pure crop of wheat at different locations (AICORPO, 1985-86). sowing of wheat + mustard or wheat + mustard + lentil in pure lines were more rewaring than their mixed sowing in same row an intercropping of wheat + mustard resulted in lower net returns compared to wheat alon at Jammu (Gupta and Singh, 1989)and Faizabad (Singh *et al.* 1992).

Net returns were higher when wheat was intercropped with mustard variety Purs Bold than IBJ-5 or IBJ-25 at Bichpur, Agra (Singh and Agarwal, 1990). suitable varieties of mustard for intercropping with wheat were PR-43 at {amtmagar. RH-781 at Hisar, Varuna at Kanpur, Faizabad and Navgaon, RW-43/11 at Berhampur (Kumar, 1983; Singh and Yadav, 1992), and Pusa Bold and Varuna at Jorhat (Das *et al.* 1992). Likewise for wheat, longer duration varieties such as WH-147 (Batra *et al.* 1987) and sonalika (Singh and Yadav 1992) for irrigated areas and C-306 for rainfed areas (Singh and Yadav, 1990; Singh and Yadav, 1992; Dwivedi and Namdeo, 1992) were more compatible.

Application of 100 Kg N per has produced significantly higher wheat equivalent yield over 50 Kg N/ha (Singh and Agarwal, 1990). Hegde and Pandey (1992) concluded that mustard did not require any additionl fertiliser at Pantnagar and Kalyani, while it required full dose at Varanasi and 50 per cent of that recommended to mustard at Navsari when it was ijtercropped with wheat. Uptake of Inutrients by component crops in ICS was higher than sole crop of wheat (Batra *et al.* 1987; Singh and Gupta, 1992).

Mandal *et al.*,(1986 a) and Batra *et al.*, (1987) registered higher consumptive use of water and water use efficiency in wheat + mustard ICS over sole crops. Further, Batra *et al.*, (1987) recommended irrigation to ICS at IW/CPE ratio of 0.60.

Post-empergence application of isoproturon @ 1.0 Kg/ha signfifcantly increased the grain yield of wheat and mustard over weedy check in wheat + mustard ICS. However, the maximum increase in mustard yield in ICS was obtained wih application of pendimethalin and fluchloralin (Panwar *et al.* 1987).

At most of the locations, intercropping of wheat with Imustard in 8-10 : 1 spatial ratio gave mustard yield as a bonus without significantly affecting wheat yeild. However for higher net returns, intercropping of wheat + mustard in 12:4 row ratio at Ludhiana and 3:1 row ratio at Tikamgarh have been recommended. Although increasing number of mustard rows increases the profit from ICS, wheat yields are reduced due to adverse effect caused by shading of mustard to wheat. Mixing of seeds of component crops reduced population and tillering of wheat (Sharma *et al.* 1986). Batra *et al.*, (1987) observed that lodging in wheat was more when it was intercropped with mustard particularly in narrow row rations. Success of wheat + mustard ICS can be ascribed to differences in rooting pattern leading to better use of resourves, Modern high yielding varieties of wheat have well developed seminal root system wherease mustard is a deep rooted crop. Due to differences in rooting pattern, there was judicious use of moisture (Mandal *et al.* 1986a; Batra *et al.* 1987) and nutrients (Hegde and Pandey, 1992).

Barley + mustard

Although yield of sole barley was more than its yeild in barley + mustard ICS, barley (Ratna) + mustard (T-59) in 4:1 row ratio resulted in higher yield of barley compared to 2:1 spatial ratio (Ali, 1975). However, the yield of barley (37.1 q/ha) in barley (Azad/Lakhan) + mustard (Varuna/ Vardan), 9:1 ICS was more than sole barley at Randhour, U.P. (Singh, 1991). Gangasaran and Giri (1985) also reported that barley + mustard in 4:1, 5:1 or 8:1 row proportion was beneficial over pure crops.

Success of component crops in ICS depends upon their vigour at initial stages and barley with quick initial growth took the advantage particularly under dryland conditions. However, its intercropping with mustard in narrow spatial ratio caused heavy shading to it. Better temporal use of water led to success of this ICS particuarly during dry years (Gangasaran and Giri, 1985).

Rapeseed + mustard

Because of thermo and photo-sensitive nature of Swede rape, it can be intercropped with Indian rape particularly in areas having assured irrigation facilities. Similarly, Ethiopian mustard can be intercropped with Indian rape under dryland conditions. Indian rape + Swede rape sown simultaneously in aalternate rows, 22.5 cm apart during mid-September gave 27.4 q/ha Swede rape equivalent yield which was 58, 99 and 83per cent more than equivalent seed yields from sole crop of Swede rape, Indian rape Swede rape and Indian rape-wheat cropping sequence (Gupta and Saini, 1986). similar results were reported from Kangra, Kanpur, Morena and Pantnagar (AICORPO, 1984-88). However, broadcasting of Indian rape in normal planted rows (45 cm apart) of Swede rape was more advantageous than line sowing of Indian rape + Swede rape and sole crops at

Faridkot, Gurdaspur and Ludhiana (AICORPO, 1984-88; Singh, 1989). The maaximum seed and oil yields of Indian ràpe + Swede rape ICS were obtained with green manuring followed by FYM and no organic manuring in that order, whereasc response of nitrogen and phosphorus was noticed upto 150 Kg N/ha and 30 Kg P_2O_5/ha, respetively (Sardana, 1990; Tanle 1). Singh (1989) found no significant effect of time of nitrogen application on yields of component crops in Indian rape + Swede rape ICS at Ludhiana. However, intercropping of Indian rape (T-9 or Bhawani) with mustard (Varuna) at Kanpu was less remunerative than mustard alone but more rewarding than Indian lrape alone. Likewise, Ethoipian mustard/Swede rape + mustard was less profitable than mustard alone (AICORPO, 1983-84).

Sahota *et al.* (1991) reported that fluchloralin @ 0.5 Kg/ha or trifluralin @ 0.75 Kg/ha applied as preplant incorporation or isoproturon @ 0.5 Kg/ha as per or post-em. (25 DAS) application proved significantly superior to weedy check in Indian rape + Swede rape ICS.

Indian rape/mustard+Pea/urdbean/linseed/winter maize

Yield of mustard increased in mustard + urdban while it decreased in mustard + pea ICS at Karjat and Shalimar, respectively. However, net returns from these ICS were higher over pure crops at both the locations (Hegde and Pandey, 1992). Faster growth and more plant height of pea compared to urdbean particularly during early sages resulted in more compețititon for light with mustard in the ICS. Shah *et al.*, (1991) reported higher yields of mustard in narrow than wider ratio when intercropped with pea. Intercropping of linseed in between rows (30 cm apart) of Indian rape or when seeds of both the crops were mixed and broadcast were more profitable than linseed and broadcast sown Indian rape but less remunerative than line sown Indian rape (AICORPO, 1984-85). Intercropping of winter maize with mustard was also more rewarding than winter maize alone at Dholi, Bihar (Prasad and Prasad, 1988) and HIsar, Haryana (Tyagi *et al.* 1994).

Summary and Conclusion

Inspite of an envious position, multiplicity of crops and crop growing situations, the total production of oilseeds is far below the requeirements and the present gap between demand and supply is likely to widen up in future. All out efforts are needed to step up the current production of oilseeds. However, due to stiff competition for land among crops and alternate uses of land, it is not possible to bring additional area under oilseeds cultivation. Rapeseed mustard share nearly one-fourth of total area and production of oilseeds in the country. Production of rapeseed-mustard *vis-a-vis* total oilseeds production can be increased by their intercropping with other crops. Available informationindicates that rapeseed-mustard can be successfully intercropped with sugarcane, chickpea, potato, wheat, barley, lintil, linseed etc. Research evidence available on the subject can be summarised as under:-

Beacuse of long duration and slow growing naute of autumn planted sugarcane, its intercropping with mustard was more profitable than pure sugarcane. Reduced incidence of frost and smut disease was found in ICS. Chickpea + mustard in 2:1, 3:1 or 4:1 row ratio was highly rewarding than their sole crops both under irrigated and rainfed conditions. Paired planting of chickpea (30/60 cm) + one row of mustard or paired planting of mustard (30/90 cm) + 2 rows of chickpea also gave higher net returns than chickpea or mustard alone. Early maturing short statured culivars such as K-468 and PDG 84-16 were more compatible with mustard variety varuna at Kanpur. Pre-emergence application of 1.0 litre of fluchloralin or pendimethalin provided

Table 1 : Influence of different treatments on the productivity of component crops in Indian rape + Swede rape intercropping system.

Treatments	Seed Yield (g/ha) Indian rape	Swede rape	Total
Manuring levels			
No organic manure	4.41	13.94	18.35
Green manure (*Sesbania aculeata*)	4.95	14.96	19.91
Farm Yard Manure (20 t/ha)	4.72	15.17	19.89
Nitrogen levels (Kg N/ha)*			
0	3.75	10.40	14.15
50	4.23	13.18	17.41
100	5.25	16.99	22.24
150	5.55	18.18	23.73
Phosphorus levels (Kg P_2O_5/ha)			
0	4.17	13.27	17.44
15	4.63	14.58	19.21
30	5.05	15.52	20.57
45	4.93	15.39	20.32

*N was applied in two equal splits: first half as basal dose and second half after harvesting of Indian rape

Source . Sardana and Sidhu (1994)

effetive control of weeds in chickpea + mustard ICS.

Intercropping of potato and mustard in 2:1 or 4:1 planting pattern was found highly rewarding. For intercroping, early maturing variety of potato and longer duration varieties of mustard were found highly compatible. application of nitrogen @ 150 kg/ha gave maximum returns.

Intercropping one to two rows of mustard with 6, 8, 10 or 12 rows of wheat, or 4 rows of mustard after every 12 rows of wheat gave higher net returns than wheat alone. There was economy in fertiliser and water use when wheat was intercropped with mustard. Isoproturon gave effective control of weeds in the ICS.

Intercropping of Indian rape with Swede rape in irrigated areas and with Ethiopian mustard in dryland areas is gaining popularity. Indian rape + Swede rape sown in alternate rows at 22.5 cm apart of broadcasting of Indian rape in line sown Swede rape (45 cm apart) was more profitable than sole crops or Indian rape- wheat croplping sequence. ICS responded to nitrogen upto 150 kg/ha and phosphorus upto 30 kg P_2O_5/ha. Weeds can be effectively controlled by pre-plant incorporation of fluchloralin (0.5 kg) or trifluralin (0.75 kg) or pre or post-emergence (25 DAS) application of isoproturon @ 0.5 kg/ha.

Thus, economically viable, tailor made, simple and easy to adopt agronomic technology for intercropping of rape seed-mustard with different crops have been generated by researchers for different agroclimatic regions of the country. Keeping in view the stiff competition for land and increasing demand of vegetable oils, there is an urgent need to popularise these practices among farmers for adoption.

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STUDIES ON SELECTION FOR YIELD IN GROUNDNUT (*A. hypogaea L.*)

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ABSTRACT

Discriminant function study on twenty-eight groundnut cultivars for seed yield revealed a progressive increase in the relative selection efficiency based on two, three and four characters over straight selection or single character selection index in both Purulia and Midnapur districts of West Bengal. But this trend is not true for five-character combinations. Maximum efficiency was observed with the selection indices based on the four characters, viz., number of pods/plant, pod yield/plant, harvest index and seed yield/plant in both the environments. Maximum emphasis should be given to these four characters during selection for higher seed yield in groundnut. These four characters also recorded higher positive b value.

Key words: Selection index, discriminant function, groundnut.

INTRODUCTION

A breeder is seldom faced with a situation in which modification of only one attribute of the crop is desired. Normally modifications are desired in several attributes. The theory of selection indices helps in manipulating several attributes simultaneously (Smith, 1936; Hazel and Lush, 1942 Robinson *et. al.* 1951). Robinson *et al.*, (1951) in corn recorded a progressive increase in efficiency of selection with the inclusion of every additional character. But selection based on three character combinations was emphasized by Singh and Singh (1972) and Narasinghani and Kashyap (1981) in peas and Dasgupta and Das (1986) in black gram. Das (1972) observed maximum efficiency in four character combinations in wheat, wereas five character combinations were more efficient in table peas (Mittal and Verma, 1991). The present study, therefore, envisages to construct a suitable selection function for improvement of seed yield in groundnut.

MATERIALS AND METHODS

Twenty-eight new selections and cultivars of groundnut were grown at Anadpur and Hatwara farm of Midnapur and Purulia disticts of West Bengal respectively, during *kharif* season of 1994 in a randamised block design with three replications. Sowing was done during the first week of July in a 5m x 5m plot for each genotype with inter-row spacing of 45cm and intra-row spacing of 10cm. Observations were recorded on ten randomly selected plants from each plot for number of pods/plant, pod yield/plant, 100-seed weight, seed yield/plant and harvest index. Harvest index was calculated as (seed yield)/(biological yield) x 100. Selection indices for seed yield were constructed according to the procedure of Smith (1936). Along with different selection indices, their expected genetic gain from different selection indices at 5% selection intensity were also calculated.

RESULTS AND DISCUSSION

Significant treatment variance for all the five characters at two different environments indicated that the genotypes included in the present study had significant variation for these traits. Different selection indices, and their expected genetic gains over straight selection (Tables 1 and 2) indicated

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that selection based on single character was less efficient than simultaneous selection based on more than one character in both the environments. It is interesting to note that the maximum gain is not realised when all the five characters under study were included in the fuction. Instead, a maximum gain of 45.88% (at Midnapur) and 43.60% (at Purulia) were observed when only four characters Viz, number of pods/plant, pod yield./ plant harvest index, and seed yield/plant were taken into account. When two characters namely number of pods/plant, pod yield/plant and seed yield/plant among the three character combinations showed higher efficiency by recording 38.98% and 32.88% in Midnapur and Purulia, respectively. The present investigation revealed that the main seed yield components in groundnut are number of pods/plant, pod yield/ plant. and harvest index. It is interesting to note that b values for above characters are high and positive in all the selection indices. Indeed, proper weightage to these characters along with seed yield during selection programme will contribute towards higher yield in groundnut.

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Table. 1 Expected gain (%) in seed yield over straight selection in groundnut from the use of various selection indices in Midnapur location.

Selection index	Expected gain (%)
Y = 0.967 X1	19.96
Y = 0.953 X2	17.15
Y = 0.874 X3	8.59
Y = 0.911 X4	6.66
Y = 0.581 X5	3.66
Y = 1.040 X1 + 1.236 X2	30.33
Y = 1.177 X1 + 1.140 X3	22.51
Y = 0.963 X1 + 1.007 X4	22.11
Y = 0.992 X1 + 0.575 X5	21.86
Y = 0.948 X2 + 0.929 X3	20.91
Y = 0.922 X2 + 0.895 X4	18.96
Y = 0.814 X2 + 0.643 X5	17.88
Y = 0.872 X3 + 0.930 X4	11.59
Y = 0.873 X3 + 0.582 X5	9.82
Y = 0.909 X4 + 0.580 X5	7.99
Y = 0.968 X1 + 0.968 X2 + 0.929 X3	29.83
Y = 2.153 X1 + 0.936 X2 + 0.874 X4	38.24
Y = 1.242 X1 + 1.307 X2 + 0.422 X5	38.98
Y = 1.398 X1 + 1.426 X3 + 0.842 X4	25.50
Y = 0.903 X1 + 0.727 X3 + 0.509 X5	21.19
Y = 0.875 X1 + 0.928 X4 + 0.901 X5	25.84
Y = 1.686 X2 + 0.132 X3 + 2.842 X4	37.23
Y = 1.024 X2 + 0.967 X3 + 0.554 X5	23.37
Y = 0.911 X2 + 1.905 X4 + 1.142 X5	23.10
Y = 0.833 X3 + 0.905 X4 + 0.783 X5	13.12
Y = 1.992 X1 + 1.127 X2 + 0.967 X3 + 0.929 X4	39.94
Y = 0.439 X1 + 1.928 X2 + 0.553 X3 + 1.573 X5	36.94
Y = 0.969 X1 + 1.298 X2 + 1.568 X4 + 1.186 X5	45.88
Y = 1.926 X1 + 0.911 X3 + 1.237 X4 + 0.444 X5	32.27
Y = 1.130 X2 + 1.371 X3 + 1.362 X4 + 0.655 X5	27.43
Y = 0.705 X1 + 1.869 X2 + 1.670 X3 + 0.890 X4 + 1.537 X5	35.29

X1 = number of pods/plant, X2 = pod yield/plant, X3 = 100 seed weight, X4 = harvest index X5 = seed yield/plant.

Table. 2 Expected gain (%) in seed yield over straight selection in groundnut from the use of various selection indices in Purulia location.

Selection index	Expected gain (%)
Y = 0.959 X1	13.38
Y = 0.937 X2	9.00
Y = 0.935 X3	11.16
Y = 0.964 X4	8.41
Y = 0.916 X5	7.13
Y = 1.840 X1 + 1.120 X2	26.61
Y = 0.951 X1 + 0.925 X3	17.47
Y = 1.342 X1 + 0.969 X4	18.86
Y = 0.967 X1 + 0.924 X5	17.84
Y = 0.931 X2 + 0.933 X3	14.46
Y = 0.926 X2 + 0.962 X4	13.72
Y = 0.963 X2 + 0.869 X5	14.98
Y = 0.937 X3 + 0.970 X4	13.45
Y = 0.922 X3 + 0.894 X5	12.14
Y = 0.995 X4 + 0.888 X5	13.65
Y = 0.968 X1 + 0.968 X2 + 0.929 X3	25.83
Y = 1.153 X1 + 0.836 X2 + 0.974 X4	24.39
Y = 1.001 X1 + 3.655 X2 + 0.854 X5	32.88
Y = 1.398 X1 + 1.426 X3 + 0.842 X4	23.93
Y = 0.192 X1 + 0.922 X3 + 0.905 X5	9.83
Y = 0.928 X1 + 0.959 X4 + 0.904 X5	21.36
Y = 1.606 X2 + 0.232 X3 + 1.842 X4	19.22
Y = 0.982 X2 + 1.395 X3 + 0.835 X5	19.57
Y = 1.901 X2 + 0.897 X4 + 0.940 X5	23.39
Y = 0.925 X3 + 2.040 X4 + 1.503 X5	17.69
Y = 0.992 X1 + 0.928 X2 + 1.067 X3 + 2.960 X4	27.11
Y = 0.913 X1 + 0.932 X2 + 0.800 X3 + 0.038 X5	22.63
Y = 1.978 X1 + 1.098 X2 + 1.158 X4 + 1.368 X5	43.60
Y = 0.978 X1 + 0.918 X3 + 1.014 X4 + 0.859 X5	28.34
Y = 1.130 X2 + 1.173 X3 + 1.236 X4 + 0.755 X5	38.78
Y = 1.000 X1 + 0.993 X2 + 0.903 X3 + 1.044 X4 + 1.537 X5	37.02

X1 = number of pods/plant, X2 = pod yield/plant, X3 = 100 seed weight, X4 = harvest index X5 = seed yield/plant.

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SCOPE OF HETEROSIS BREEDING IN RAPESEED-MUSTARD

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ABSTRACT

It is now expected that the development and utilization of hybrid cultivars in rapeseed-mustard through heterosis breeding would be a worth-while approach in enhancing their productivity. In this paper, different aspects of heterosis breeding viz., prerequisites for the development of hybrids, different existing hybrid systems, extent of of outcrossing, recent advances in India and abroad, limitations of lhybrids in *Brassicas* and future strategies has been dealt. As it is seen, every aspect of heterosis breeding is available in rapeseed-mustard. So, there, is plenty of scope for heterosis breeding in rapeseed and mustard.

Key words : Heterosis, hybrids, *Brassicas*

INTRODUCTION

Rapeseed-mustard group of crops have a significant role in human dietry system and in the national agriculture economy. Rapeseed-mustard contributes to 30 per cent of total oilseed production and is only second to groundnut. The average yield of rapeseed and mustard in India and world is 944 kg ha^{-1} and 1306 kg ha-1, respectively. To boost up further productivity of rapeseed mustard crop, it has been envisaged that exploitation of heterosis and development of hybrids may play a significant role in coming years.

Breeding procedures are mainly confined to selection, recombination and induced mutations. The improvement through these approaches are tending to level off, since these approaches do not mobilize sufficient amount of genetic diversity. Hybrids offer an opportunity for mobilizing a greater amount of genetic variation and heterotic response. Hybrids have the following advantages :

1. Yields are high as a result of heterotic response,
2. Desirable dominant characters are readily combined,
3. Crop development and harvested products are uniform owing to genetic homogeneity,
4. Hybrids have better adoptability to environment and other stresses due to their better buffering capacity of individual and population as compared to pure line varieties.

The productivity level of hybrids can be compared to national average (Table 1).

Keeping these advantages in view, heterosis breedings in cultivated oilseed *Brassica* crops is the need based crop improvement method.

For a successful hybrid breeding programme it is essential that a method is available for commercial production of hybrid seed economically.

Pre-Requisites for the Development of Hybrids:

For a successful hybrid breeding programme, it

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Table 1: **Productivity level (T/ha) of Hybrids in relation to national average (Paroda, 1993).**

Country	Crop	National Average	Realizable	Genetic
CHINA	RICE	5.50	7.5	9.0
	MAIZE	4.60	8.0	10.0
INDIA	MAIZE	1.80	5.0	7.5
	SORGHUM	0.90	2.0	7.0
	PEARLMILLET	0.50	2.0	3.5

is essential that (1) significant heterosis is available in the F_1 hybrids, (2) a method is available for commercial production of hybrid seed economically and (3) extent of natural outcrossing.

1. Heterosis

The demonstration of heterosis in a crop species is not adequate. Justification for the adoption of a commercial hybrid by the farmers depend upon the relative cost of the seed and the extra economic gain obtained through the enhancement of the yield by the use of the hybrids over the cultivated variety. Depending on the yield level and usually a margin of 20-50 per cent of the standard heterosis seems to be reasonable limit. For the crop with lower level of production, the amount of heterosis needed may be comparatively high and varying according to the level of production.

The earliest report on the superior performance of F_1 hybrids in oilseed *Brassica* is by Hoing in 1940 (Dass and Rai,1972) followed by singh and Mehata (1954). Since then a number of studies have been carried out in different species of the genus *Brassica*. Significant levels of heterosis with respect to seed yield and its component attributes have been reported (Table 2).

Svensk (1963) observed 30-40 per cent heterosis in seed yield in crosses between Indian and European types of *B. campestris*. In *Brassica napus*, Shiga (1976) found that hybrids between Japanese and European type varieties showed greater hybrid vigour than croses between varieties within these two different types.

Since there is a wide range of yield heterosis of 10-154 per cent, theoretically, there is a good margin for producing commercial hybrids.

II. Hybrid Systems :

There are several approaches that are being utilized in developing economic hybrid system while some are using genic male sterility, others the self incompatibility system and still others, the *cytoplasmic* male sterility.

1. Genic male steriles

(a) *Brassica campestris:* Pandey (1961) in brown sarson and Chowdhary and Das (1966) in yellow sarson reported genic male sterility and suggested a procedure for producing hybrid seeds. Using genic male sterility for hybrid seed production is more advantageous in self fertile brown sarson and yellow sarson where the process of bud

Table 2: Significant levels of heterosis with respect to seed yield and its component attributes.

Spiecies	Heterosis(%)	Character	Authors
Brassica juncea	47	Seed yield	Singh and Mehata, 1954
	19-102	,,	Dass and Rai, 1972
	8-54	,,	Jawaid & Srivastava, 1983
	13.8-112.2	,,	Thakur & Bhateria, 1993
	19.2-34.8	,,	Shi *et al.* 1993
	25-154	,,	Rai, 1983
	6.58-8.23	Oil content	Shi *et al.*, 1993
B.compestris	10.45	Seed Yield	Singh & Mehata, 1954
(Brownsarson)	10.45	,,	Bandopadhya & Arunanchalam, 1980
	25	,,	Singh, 1958
	Marked	,,	Singh and Asthana, 1972
Yellow Sarson	2-63.7	Seed/Siliqua	Labana *et al.*, 1978
	95	Seed yield	Labana *et al.*, 1983
	30	Seed yield	Kumar, 1983
B. napus	38-43	Seed yield	Stefanson, 1983

pollination is not essential for the maintenance of inbred lines.

(b) *Brassica juncea* (Mustard): Banga and Labana (1983) observed spontaneously occuring male sterile plants in open pollinated population of a German introduction, ES-37. The genetic analysis suggested that the single recessive gene was responsible for male sterility. Most of the Indian types were found to be restorers. In the two cases, maintainers have been obtained in European types (Labana, 1983).

(c) *Brassica napus*: Ling and Yan (1983) reported the isolation and utilization of genic male steriles on commercial basis. The F1 hybrids under yield trials showed and yield advantage ranging from 20.7 to 45.6 per cent over the standard variety.

One of the limitations of this system is that it requires a large amount of hand labour for hybrid seed production in the field and roguing of the plants in the field and as such it may not be economical.

2. Cytoplasmic male sterile-genetic restorer system

Presence of genic male steriles have not helped much in producing hybrid seed, as they do not provide 100 per cent male sterile line in production plots. It becomes practically difficult and economically undesirable to uproot about 50 *per cent plants before flowering, therefore cytoplasmic* male sterile genetic restorer system is the most economic system which is preferred by the plant breeders for hybrid production.

(a) *Raphanus cytoplasm in Brassica napus: Ogura system: Cytoplasmic* male sterility was identified in radish by Ogura (1968). Here the sterility was controlled by monogenic recessive nuclear genes (ms ms) and a sterility inducing *cytoplasm*(s). The nucleus of *B. oleracea* was transferred into this radish *cytoplasm* (Bannerot, 1975). Subsequently, cms *B. napus* was produced by repeated back crossing (Bannerot, 1977). Studies with *Raphanus* cms *B. napus* system has shown that the male sterility of the cms plants is excellent under wide array of growing conditions. The restoration of fertility, however, remains a problem although introgression of restorer genes from *Raphanus* into cms *B. napus* has been achieved by Heyn (1978).

(b) *B. campestris cytoplasm* in *B. napus*: Ohkawa system: Ohkawa (1981) discussed a male sterility in *B. campestris*. Some of the cultivars of *B. campestris* had no gene for restoration of pollen fertility in cms while others had gene (s). The male sterile *cytoplasm* found in *B. campestris* induced male sterility in *B. napus* as well (Ohkawa, 1983). It thus seems useful to utilize the male sterile *cytoplasm* of *B. napus* as well as that of *B. campestris* in the F1 hybrid system.

(c) *Bronowaski-Shiga-Thompson cms system* : This *cytoplasmic* male sterility was first described by Thompson (1972). The identified cms plants in the F2 generation of crosses between summer and winter rape (*B. napus*) cultivars in which the summer *B. napus* cultivar Bronowaski, was used as the male parent. This type of male sterility is very unstable, with the sterility breaking down at high temperature. Because most *B. napus* cultivars varry restorer genes for this type of cms, it is difficult system to work with. Shiga *et* al., (1983) reported that out of 71 European cultivars tested in Japan, only one cultivar, Bronowaski did not have restorer genes.

(d) *Polima* cms : The Polima cms is the most promising cms system in *B. napus*. It was first time reported by Fu in 1981. It is reported to have stable male sterility under various environments. Restorer genes are available and restoration of male fertility in the hybrids seems to be satisfactory. Reports indicate that restoration of pollen fertility is controlled by one major gene (Buzza, 1984). The first commercial *B. napus* hybrid, based on the Polima system appeared in Canadian official trials in 1986. Unfortunately, under high temperature the male sterility of this cms is not complete and the potential heterosis, as measured in increased seed yield has not been fully recovered, when the parents have been put into the Polima back ground. (Mc Vetty *et al.* 1990). recently it has been reported that a new Chinese *B. napus* hybrid 'Chin You-2' resulting from a cross between European and Chinese parents, has proved to be extremely productive (Fu-1990). Still, it is not known whether this hybrid is modification of Polima cms or whether it is, in fact a new system altogether.

(e) *B. juncea* based cms system: In Brassica juncea *cytoplasmic* male sterility was first time reported by Anand and Rawat in 1979. The sterility is stable under various environments. Fertility restorer genes for this cms system have been identified in other Brassica species. *B. campestris* and *B.nigra* being the most effective. By crossing these twospecies it is hoped that fertility restoration can be increased (Anand *et al.* 1985). According to Anonymous (1982) among the various interspecific and intergeneric crosses the following crosses restored partial fertility:

1. Ms *B. juncea* X B. nigra (one line)
2. ,, X *B. campestris* (one line)
3. ,, X *B. napus* (one line)
4. ,, X *B. juncea* (Wild) (Two plants)
5. ,, X *Sinapis arvensis* (few plants)

The ms lines were also crossed with more than 100 fertile lines of *B. juncea* to search for pollen fertility restoring varieties. None of the crossed material restored fertility. Indicating there by the permanent nature of *cytoplasmic* sterility.

(g) Diplotax is muralis cms system: (Mur *cytoplasm*): The utilization of heterosis in hybrid cultivars of *B. campestris* would require a workable cms system. Such a system has been developed by crossing and back crossing the vegetative type *B. campestris* Yukina into *Diplotaxis muralis* (Hinatu and Konnel, 1979). The resulting cms *B. campestris* cultivar had stable male sterility. Restorers have been identified for this system. However, the genes for maintenance of cms will have to be transferred into adopted oilseed forms of *B. campestris* before hybrids will be economically feasible. The number of restoring genes, however, needs to be known which are responsible for restoration. Attempt is also being made to incorporate mur *cytoplasm* into *B. juncea* (Hinata, 1983).

(h) Brassica oxyrrhina cms system: Recently, Prakash and Chopra (1990) synthesized male sterile lines caused by *cytoplasm* of *B. oxyrrhina* in *B. campestris* and *B. juncea*. Alloplasmic plants obtained in ECs generation were stable male sterile but mildly chloritic during initial development. The efforts are under way to identify/develop restorers.

3. S-allele system :(Self-incompacibility): B. campestris is characterized by a sporophytically determined self incompatibility system which leads to almost complete out crossing. Self incompatibility can be overcome by bud pollination and inbreeds can be obtained. These inbreeds show high level of inbreeding depression and are very difficult to be maintained through contained selfing. Self-incompatible plants have been mostly found in *B. napus* trial, but selfing of self-compatible plants have resulted in segregation of self-incompatible genotypes. Thompson (1983) proposed a scheme for the production of self-compatible three way cross hybrid of *B. napus* (Fig 1).

A major drawback of the scheme is the difficulty of producing commercial quantities of selfed seeds on the SI parent lines. Thompson (1983) suggested growing plants in polythene tunnels in which dry ice (CO_2) was placed twice in a week during the flowering rim and increase CO_2 concentrations in the air, which increased seed set on SI lines. This method has not been used commercially. Siping (1985). demonstrated that 5 per cent salt water is the suitable concentration to overcome incompatibility. This report revealed that during flowering period spraying salt under every 3-5 days is effective. This method is economical and easy and its effect *is equal to that of bud pollination*.

This system is being commercially used for hybrid seed production in some Brassica species in Europe and Japan.

Three way cross hybrid to show commercial crop.

Homozygous deploid lines	A	sf	sf	X	B	sf	sf
S alleles (HD L-S-alleles)	(SI)				(SI)		
	AB	sf	sf	X	Compatible		HDL
	(SI)					Sf	Sf
	F_1 hybrid						
				ABC	(All	SF	SF)
				(SC)			

Fig. 1: Possible method for production of SC three way cross.

4. Chemical induced male sterility:

Chemical emasculation without any negative side effect (mainly on female fertility) and subsequent cross pollination is another efficient system for hybrid production. Such a system, if it could be depended upon to be hundred per cent effective under varied environments, could be the quick answer to hybrid production.

In China, male gametocide No. IMG-4 and other chemical substances are effective, which can kill pollen grains more than 80% and found that microsporogenesis was the most sensitive period.

In India, Banga and Labana (1983) used Ethrel induced male sterility to produce F1 hybrids in *B. juncea*. But F_1 hybrid showed carry over effects due to Ethral treatment. It is argued that Ethral induced male sterility has only a limited role in screening parental combinations for their yield assessment.

II. *Extent of outcrossing:* Varying amounts of self and outcrossing occurs in the different species and strains. *Brassica juncea* (Mustard or Rai) is self fertile and largely self-pollinated. Certain amount of outcrossing takes place, through inserts estimates varying from 4-14 per cent. Likewise, in *B. campestris* (Yellow sarson and torial from of brown sarson) 5 to 12 per cent of natural outcrossing had been observed (Singh, 1964). The lotani type of brown sarson and toria are cross pollinated, being self-sterile (sterility means-self incompatibility of pollen and stigma). In general, *B. juncea* and *B. napus* are often mainly self pollinating, but under field condition 30 per cent of outcrossing occurs (Rakow and Woods, 1987). Since there is a wide range of cross pollination (5-99 per cent) in these crops, views have often been expressed to produce superior performing commercial hybrids.

Recent Advances in India and Abroad :

The most advanced country in the use of hybrids is China, where some 4 lakh ha of *B. napus* hybrids are reported to be in production. The genic hybrid system developed by Chinese Academy of Agricultural Science (CASS) at Shangi, has been under production. Recently, it has been reported that a new Chnese, *B. napus* hybrid "Chin you-2" (using 'Polima cms') resulting from a cross between European and Chinese parents, has proved to be extremely productive and is under cultivation in China. Due to shortcomings of the present cms restorer system, some commercial companies are now turning to the use of hybrids. Several such hybrids are now in Cnadiall trials and their performance is promising.

In India, in recent years, the *Brassica* breeders are seriously exploring the possibilities for the exploitation of available heterosis response, through male sterility. Chinese are first in the world to have gone to the farmers field with oilseed *Brassica* hybrids, obtaining 30-35 per cent yield increase. Based upon the exchange of views between the Indian and Chinese scientists, a mutually agreed collaboration in the field of heterosis breeding was started in India and China under project namely "INDO-SINO PROJECT" in 1991. The participating institutions are listed in Table 3.

The objectives were :

1. Evaluate *B. campestris*, *B. juncea*, *B. napus* hybrids in India and China.
2. Exploitation of male sterility systems.

Keeping these objective in view, intensive researches are on and fruitful results are awaited.

In India, the progress of work on development of *Brassica* hybrids up to 1990 were compiled by PC unit (Rapeseed and mustard) HAU, Hissar and the results are summerised here:

1. *Search for restorer genes :* Efforts are on to identify the fertility restoration in the cms lines.

Table 3 : List of participating institutions under Indo-sino Project, 1991.

Name of the crop/ species	Institutions	
	Indian	Chinese
B. campestris	*I. GBPUA&T, Pantnagar*	*Siachuan Academy of Agril. Science.*
	II. RAU, Dholi	Oinghai Academy of Agril. Science.
B. juncea	I. IARI, New Delhi	Yannan Academy of Agril. Science
	II. P.C.Unit, Hissar	*Xinjiong Academy of Agril. Science.*
B. napus	I. PAU, Ludhiana	Hauzhang Agricultural University.
	II. HAU, Hissar	Inst. of Oil Crops CASS

Table 4: Performance of Indian mustard hybrids in large scale trial against check variety (1989-90)

Name of the hybrids/ varieties	Seed yield (kg/ha)	Maturity (days)	Oil content (%)
PHR-1	2042.81	145	36.03
PHR-2	2976.06	142	38.50
RH-30 (Local check)	2153.04	135	38.57
Varuna (National check)	2428.28	139	40.46
Krishna(National check)	2127.96	143	41.72
Kranti(National check)	1998.36	143	39.48

To make use of ms in hybrid development, 300 crosses have been attempted using cms lines, Ogura, Polima & Anand as female parents. To search the restorer genes a number of germplasm lines, synthesized *B. juncea* lines and breeding lines were used as pollen parents. *B. napus* were also used in crossing programme.

2. *Evaluation of Indian mustard hybrid:* Two hybrids of *B. juncea* developed by the PAU, Ludhiana were evaluated against RH-30, Varuna, Krishna & Kranti. A perusal of Table 4 reveals that hybrid PHR-2 significantly yielded out the highest yielding check variety.

3. *Identification of effective male sterility system:* To identify suitable male sterility system, different crosses were attempted with different systems and evaluated for their stability in different environmental conditions.

The present status of hybrid Brassica in India, was summarized by Rai (1994) and he advocated that among the 4 experimental hybrids in trial during Rabi 1992-93, none could out yield the national check 'Kranti'. However, in Zone 1. The hybrid PHR-16' gave 14.4% better performance over the local check 'RI-1359'. During Rabi 1993-94, two hybrids 'PHR-16' AND 'PMH-3' marginally out yielded 'Kranti'.

A total of 784 and 3292 crosses have been studied and scored for identifying fertility restorers during 1992-93 and 1993-94, of which, 39 complete and 69 partial fertility restorer crosses could be spotted.

Limitations of Hybrids in Brassicas :

1. Unstability of male sterility.
2. Absence of perfect maintainer and restorer lines.
3. Poor seed set.
4. Lack of better combinations.
5. Inadequate production and supply of good quality seeds.

Most of male sterile systems are unstable over environmental conditions. Polima cms do not show complete sterility at lhigh temperature. Where complete sterility is there, like Anand system, problem of perfect maintainer, and complete restorer is observed. Poor seed set in hybrids production is observed owing to limited outcrossing. Mc Vetty *et al.*, (1990) reported that potential heterosis had not been lobserved in Polima cms hybris, so more combinations have to be tested in order to get the hybrid showing substantial advantage over varieties (National check). If the farmers will go for planting the advanced generation (i.e.F_2) seeds of the commercial hybrids, they should be prepared to suffer an yield loss of 12 per cent and one per cent loss in the oil content in the case of mustard hybrids and 15 per cent in rape hybrids. Hence Procurement of seed every crop season is necessary which require farm resource dependence/ Efficient infrastucture to produce and supply good quality seeds is needed.

FUTURE STRATEGIES:

Search for better performing CMS hybrids, stable CMS A, B and R lines and perfection of seed production techniques have been suggested to be the worth while strategies to be followed in the years to come.

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COMBINING ABILITY IN SESAME (*Sesamum indicum* L.)

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ABSTRACT

Twenty genotypes of sesame and three testers were crossed in line X tester fashion to assess the combining ability of lines. The parents and F1s were evaluated for their seed yield per plant. Among the lines S-0558, S-0561, RJS-2 and Si-264-1 recorded significantly high yield. The lines S-0584, TMV-5 and the tester SVPR-1 were good general combiners for seed yield. Among the crosses, S-0584 X SVPR 1 showed additive gene action and high mean seed yield and can be chosen for pedigree breeding for varietal improvement. The crosses IS 345 X Si 1770 and TMV 5 X Si 1770 showed nonadditive gene action and high seed yield per plant and hence the selection should be postponed to later generation.

Key Words : Sesame, combining ability, seed yield.

INTRODUCTION

Sesame (*Sesamum indicum L.*) is an important oilseed crop in India. Sesame yields are very low since it is grown in marginal and sub marginal lands. Allard and Bradshaw (1964) suggested that heterozygous and heterogeneous population offer the best opportunity to produce varieties which show small genotype X environment interaction. Hence heterosis breeding is one of the avenues to overcome the low yield in sesame. In any breeding programme, critical choice of parents is important, particularly in the case of heterosis breeding. The present study was carried out to estimate the combining ability of parents and heterosis of hybrids for seed yield.

MATERIALS AND METHODS

The trial was conducted at National Pulses Research Centre, Vamban during Summer, 1995. Twenty genotypes of sesame were chosen as lines and crossed with three testers *viz*., SVPR-1. CO-1, and Si-1770. All the 60 crosses and 23 parents were sown in a Randomized Block Design with three replications. Each entry was sown in a single row of 4 meters adopting a spacing of 45 X 20 cm. Recommended cultural practices were followed. Ten competitive plants were chosen to record the seed yield per plant per replication. The analysis of combining ability was done according to Kempthrone (1957).

RESULTS AND DISCUSSION

Analysis of variance (Table 1) showed significant differences among parents, hybrids and crosses vs parents. Analysis of variance for combining ability revealed that Variance due to testers and line X tester were significant, while variance due to lines was not significant. The variance due to specific combining ability was greater than the magnitude of general combining ability which indicated the predominant role of non-additive gene effects in the expression of seed yield as reported by Dixit (1976), Fatteh *et al.*, (1982). Chaudhari *et al.*, (1984). Dura and Kamala (1987) and Ramalingam *et al.*, (1990).

The mean Performance and combining ability for seed yield were presented in Table 2. Among the 20 lines, S-0558, S-0561, Si-264-1 and RJS-2 recorded significantly higher *per se* seed yield per plant. While considering the general combining ability, the lines viz., S-0584, TML-5 and the tester SVPR-1 recorded significantly positive effect of 2.76, 4.02 and 0.85, respectively, while the genotype Si 264-1 recorded significantly negative *gca* of -1.48. These clearly showed that the *per se* performance of parents was not an

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Table 1 : ANOVA for combining ability for seed yield in sesame

Source	df	MS
Hybrids	59	13.95*
Lines	19	14.16
Testers	2	45.62*
L X T	38	12.18*
Parents	22	14.37*
Crosses Vs Parents	1	49.49*
Error	82	2.59
gca		0.026
sca		4.800

*significant at 5% and 1% level respectively

indication of their combining ability. This was in accordance with the finding of Fatteh *et al.* (1995). Griffing (1956 and 1965) suggested that high *gca* effects are related to additive gene effects or additive X additive effects which represent the fixable genetic components of variance. In view of this, S-0584. TMV-5 and SVPR-1 could be utilized for hybridization programme to get good segregants for seed yield.

The *per se* performance of the crosses revealed that S-0558 X SVPR 1, S-0584 X SVPR 1, S.0606 X CO1, IS 345 X SI 1770 and TMV 5 X Si 1770 recorded significantly high seed yield per plant. None of the high yielding parents were involved in the high yielding crosses indicated that the *per se* performance of parents need not be an indicator for their heterotic potential. While considering the *sca* effects, the crosses viz., S.0606 X Co 1, S.0609 X Co1, IS 345 X Si 1770, IS 359 X Si 1770 and TMV 5 X Si 1770 recorded significant positive effect. The gene action involved in the crosses which recorded significant *sca* effects may be of dominance or epistatic nature. In contrast to *gca* effects, *sca* effects represents dominance and epistatic effect that are non-fixable. Hence, the selection in these crosses has to be postponed to later generations. The crosses viz., S.0584 X SVPR 1 and TMV 5 X SVPR 1 recorded not significant *sca* effect and their parents had high *gca* effects indicating additive gene action involved in the crosses.

Due to the presence of additive gene action and high *per se* performance of parents and crosses, the cross S. 0584 X SVPR 1 can be chosen for varietal improvement through pedigree breeding. Though the crosses IS 345 X si 1770 and TMV 5 X Si 1770 recorded high mean performance, due to the presence of non-additive gene action involved in the crosses, selection has to be postponed to later generations.

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Table 2 : Mean Performance and combining ability of parents and hybrids for seed yield in sesame.

Genotypes	Parents		Hybrids					
	Mean	*gca*	Mean			*sca*		
			SVPR1	CO 1	Si 1770	SVPR 1	CO 1	Si 1770
S 0549	7.70	-1.01	9.60	7.70	6.20	0.92	-0.48	-0.43
S 0558	12.10	0.84	1220	9.30	7.55	1.67	-0.73	-0.93
S 0561	11.40	-1.24	7.40	8.60	6.80	-1.05	0.65	0.40
S 0584	8.50	2.76*	14.00	10.90	9.90	1.55	-1.05	-0.50
S 0606	5.80	-0.94	4.70	13.90	5.10	-4.05*	5.65*	-1.60
S 0609	5.30	-1.26	5.20	11.20	6.35	-3.23*	3.27*	-0.03
IS 45	6.60	0.63	10.60	8.90	8.90	0.28	-0.92	0.63
IS 207	3.10	0.62	8.80	11.60	8.00	-1.52	1.78	-0.27
IS 345	7.90	0.37	8.60	5.40	13.65	-1.47	-4.17*	5.63*
IS 359	10.70	0.23	8.70	7.90	10.60	-1.22	-1.52	2.73*
IS 264-1	10.80	-1.48*	10.70	8.80	2.60	2.49*	1.08	-3.57*
IS 553	5.80	0.01	11.20	9.05	6.30	1.50	-0.15	-1.35
RJS 2	11.30	-0.38	10.50	9.10	5.80	1.19	0.28	-1.47
8452	9.60	0.63	10.50	9.30	8.30	0.18	-0.22	0.03
8479	5.70	-2.51*	7.40	6.40	5.20	0.22	-0.28	0.07
BS 6-1	3.20	-1.94*	7.60	8.50	4.60	-0.15	1.25	-1.10
TMV 5	10.50	4.02*	14.10	8.80	15.70	0.39	-4.42*	4.03*
SI 45	8.20	-0.44	10.80	9.10	5.30	1.55	0.35	-1.90
SI 587	7.50	-0.07	9.60	10.30	6.40	-0.01	1.18	-1.17
GENE 9101	6.40	1.16	11.60	8.80	9.60	0.75	-1.55	0.80
S.E. (lines)	-	1.21	-	-	-	-	-	-
SVPR 1	3.50	0.85*	-	-	-	-	-	-
CO 1	8.20	0.35	-	-	-	-	-	-
SI 1770	5.80	-1.20*	-	-	-	-	-	-
S.E. (testers)	-	0.47	-	-	-	-	-	-
S.E.	2.09	-	-	2.09	-	-	2.09	-

* Significant at 5% level

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INHERITANCE OF ACHENE YIELD AND ITS COMPONENTS IN A SUNFLOWER POPULATION

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ABSTRACT

Ninety six full -sib and 32 half sib groups were produced using N.C.1 design in EC 68414 population of sunflower and evaluated for 13 morpho-physio-logical traits. Dominant component of variance was more important for all the chaacters except days to 50 per cent flowering and moderate for biological yeild and seed yield. Simple selection is suggested for the improvement of these characters. It was low for number of seeds per head, percentage of filled seeds and head diameter. Family selection based on progeny performance should be used for the improvement of these traits. Average degree of dominance (d) revealed over dominance for all the characters. Recriprocal recurrent selection to capitalize the dominance variance in the population is suggested.

Key words : Sunflower, N.c.-1 design, heritability, variance-components, degree of dominance.

INTRODUCTION

Oilseeds are important crops for Indian agriculture. They not only provide edible oils that constitute an indispensable component of Indian diet, but also are renewable sources of hydrocarbons and CO_2 neutral (Murphy, 1993). India, having, largest cultivated area under oil seeds in the world, has been chronically deficient in per capita supplies of fat and oils. Sunflower is an important oilseed crop with the potentiality to combat the increasing gap of oils requirement. However, this crop contributes only 5.8 per cent share in oil production in the country. This is because of non-availability of high yielding varieties of sunflower. A knowledge on the nature and magnitude of genetic variance of yield and its components is useful in making breeding plans to evolve high yielding varieties. However, very limited studies have been performed on this aspect in sunflower. The present investigation was carried out to obtain information on genetic components of variance in EC 68414 population of sunflower.

MATERIALS AND METHODS

From EC 68414 population of sunflower a random sample of 32 male plants were selected and each male plant was crossed to 3 randomly selected female plants. No female was repeated with another male. In this way 96 full-sib and 32 half sib groups were produced. For field evaluation, the material was grouped into sets within a block (Comstock and Robinson, 1952). Each progeny was grown in a single row of 3 meter length accommodating 10 plants within a row. The distance between two rows was kept 60 cm, Statistical analysis was performed according to Comstock and Robinson (1952).

RESULTS AND DISCUSSION

Mean squares due to males in sets as well as females in males in sets were significant for all 13 morpho-physiological characters (Table 1). This indicated that considerable amount of genetic variability existed for all the morpho-physiological characters and are amenable to

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improvement. The variance components due to males as well as females were significant for all the 13 morpho-physiological characters (Table 2). However the magnitude of female variance was higher than male components for all characters. Dominant component was more important than the additive component for all the characters except days to 50 per cent flowering.

Narrow sense heritability could be estimated only for 12 morpho-physiological characters due to a negative estimate of additive variance in 100-seed weight (Table 2). Narrow-sense heritability was moderately higher for days to 50 per plant (0.56), moderate for biological yield (0.43) and seed yield per plant (0.46). Hence, there was ample opportunity for genetic manipulation of those characters through selection in the population. These results are in agreement with those of Singh and Yadav (1986) and Dilruba Begum *et al.* (1988). However, it was below moderate for stem diameter (0.31) and plant height (0.35) and low for number of seeds per head, percentage of filled seeds and head diameter. Rest of the characters exhibited very low heritability. Family selection based on progeny performance should be practiced to obtain genetic gain in these characters.

The magnitude of average degree of dominance revealed over-dominance for all the characters (Table2). Conclusively, the results indicated that dominance component of genetic variance (σ^2D) was of higher magnitude for all the morpho-physiological characters except days to 50 per cent flowering. These results are compatable with a number of reports in sunflower. Role of dominance component of variance is well documented in sunflower for various characters such as seed yield (Marinkovic, 1993). days to maturity (Singh *et al.* 1986), head diameter (Singh *et al.* 1986), stem diameter (Dua and yadava, 1983), number of leaves per plant (Rao, 1980), 100-seed weight (Singh *et al.* 1986), plant height (Singh *et al.* 1986), Harvest index (Cecconi and Baldini, 1991), number of seeds per head (sheriff *et al.* 1985), percentage of filled seeds (Singh *et al.* 1986), and husk content (Pathank *et al.* 1985). The additive genetic component was found important for days to 50 per cent flowering. Similar results have been reported by Dua and Yadava, (1983) and Singh *et al.*, (1987). On the other hand, several workers have demonstrated the importance of additive component in sunflower for seed yield (Anashchenko 1974), head diameter and 100-seed weight (Rao and Singh, 1977). The discrepancy among the results may be due to the reference population and mating design used in different studies. Average degree of dominance (d) indicated the presence of over dominance for all the characters, conforming again the earlier inference drawn about the preponderance of dominance genetic variance in the population. These results are in agreement with Singh *et al.*, (1986).

Importance of non-additive genetic variance in sunflower had also been emphasized for a number of characters by Putt (1966) and Sudhakar (1979). However, it has been concluded by some workers (Gardner *et al.* 1953) that the over-dominance could result from repulsion phase linkages involving genes no more than partially or completely dominant to their alleles. Therefore, values of (d) in excess of unity do not necessarily distinguish true over-dominance in the action of alleles from pseudo over-dominance or over-dominance at the gametic level. However, it may be mentioned here that the chances of over-dominance due to repulsion linkage are rare in this population being maintained by open pollinating system of mating for more than two decades. Hence, Ec 68414 population should be in the state of linkage equilibrium.

From the above discussion, it may be concluded that dominance component of variance is more important in this population. Hence, population improvement programme capitalizing upon the dominance variance should be used for its genetic improvement. Use of reciprocal recurrent selection would improve the potentiality of this population to provide good nicking inbred lines in the hybrid combinations.

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Table 1. Analysis of variance of 13 morpho-physiological characters in sunflower population

Source of varition	D.F.	Days to 50% flowering	Days to maturity	Stem diam (cm)	Head diam (cm)	No. of leaves/ plant	Plant height (cm)	Biological yield/ plant (g)	Seed yield/ plant (g)	Harvest index (%)	Husk content (%)	No. of seeds/ head	% age of filled seeds	100-seed weight (g)
Sets	7	4.61	22.43	0.86	18.44	17.38	328.17	10460.11	437.83	7.34	15.65	753614.66	100.51	10.01
Replications in set	8	0.49	1.99	0.02	2.33	2.82	29./10	298.76	14.70	0.44	0.76	8924.93	4.65	0.03
Males in sets	24	28.51*	49.93*	0.53*	17.05*	18.40*	666.55*	11851.24*	438.44*	6.70*	18.38*	254716.10*	118.17*	1.27*
Famales in Males in sets	64	11.23*	32.16*	0.29*	10.33*	17.88*	341.42*	5302.76*	189.76*	5.81*	15.76*	157154.35*	70.49*	3.07*
Pooled error	88	1.26	1.88	0.03	1.18	2.45	36.66	365.53	14.89	0.55	1.49	7363.39	3.86	0.02

Table 2. Estimates of components of genetic variance and their ratio for 13 morpho-physiological characters in sunflower population

Items	D.F.	Days to 50% flowering	Days to maturity	Stem diam (cm)	Head diam cm)	No. of leaves/ plant	Plant height (cm)	Biological yield/ plant (g)	Seed yield/ plant (g)	Harvest index (%)	Husk content (%)	No. of seeds/ head	% age of filled seeds	100-seed weight (g)
σ^2f	4.99 *	15.14 *	0.13 *	4.58 *	7.72 *	152.38 *	2468.61 *		87.44 *	2.63 *	7.14 *	74895.48 *	33.32 *	1.52 *
σ^2m	2.88 *	2.96 *	0.04 *	1.12 *	0.09 *	54.19 *	1091.41 *		41.45 *	0.15 *	0.44 *	16260.29 *	7.95 *	-0.30 *
	± 1.36	± 2.49	± 0.03	± 0.84	± 1.00	± 32.36	± 569.02		± 21.00	± 0.35	± 0.96	± 12626.25	± 5.83	± 0.11
σ^2A	11.52	11.85	0.16	4.48	0.35	216.75	4365.65		165.79	0.59	1.74	65041.17	31.79	-1.20
	± 5.43	± 9.96	± 0.10	± 3.37	± 3.39	± 129.46	± 2276.07		± 84.00	± 1.41	± 3.86	± 50505.01	± 23.33	± 0.43
σ^2D	8.43	48.72	0.36	13.82	30.53	392.77	5508.81		183.95	9.95	26.81	234540.74	101.48	7.29
	± 6.70	± 15.00	± 0.14	± 4.94	± 7.43	± 176.09	± 2932.70		± 106.96	± 2.47	± 6.72	± 74493.02	± 33.88	± 1.15
$h^2(n)$	0.56	0.19	0.31	0.24	0.01	0.35	0.43		0.46	0.05	0.06	0.21	0.24	-
	± 0.26	± 0.16	± 0.19	± 0.18	± 0.12	± 0.21	± 0.23		± 0.24	± 0.13	± 0.13	± 0.17	± 0.17	-
$\bar{d}$	1.21	2.87	2.09	2.48	13.2	61.90	1.59		1.49	5.81	5.54	2.69	2.53	-

σ^2f = Female varianc, σ^2m = male variance, σ^2A = aditive variance, σ^2D = dominance variance, $h^2(n)$ = narrow sense heritability
$\bar{d}$ = average degree of dominance.

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CONSTRUCTION OF SELECTION INDICES FOR VARIETAL SELECTION IN SUNFLOWER (*Helianthus annuus* L.)

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ABSTRACT

The efficiency of selection can be increased by the use of selection indices formulated through discriminant function technique. Selection indices were computed using mean values of 225 accessions of sunflower (*Helianthus annuus* L.) representing diverse germplasm from as many as 24 countires. Although maximum relative efficiency could be realized when all the four characters *viz*., plant height, head diameter, weight of head and number of filled seeds are involved in formulating selection index, the characters plant height and number of filled seeds combination should be emphasized.

Key words: Discriminant function, relative efficiency, selection indices, sunflower.

INTRODUCTION

Yield is a complex character which cannot be improved to a greater extent on its own. It is influenced by several components which are related among themselves and with the yield either directly or indirectly. Thus direct selection for yield often proves to be ineffective. As an alternative to straight selection for seed yield, selection can be based on a combination of yield parameters formulated in the form of selection index on the discriminant function technique. Not many attempts have been made to construct selection indices as far as sunflower crop is concerned. Thus the present study was taken up.

MATERIALS AND METHODS

The experiment consisting of 225 accessions originating from as many as 24 countries, was laid out in a 15 x 15 simple lattice design, during dry season of 1992 under irrigated conditions. A spacing of 60 cm between the rows and 30 cm between plants in a row was adopted. The observations were recorded on 10 randomly selected plants to estimate genetic variability parameters and correlations. Five characters viz., plant height (X_1), head diameter (X_2), weight of head (X_3), number of filled seeds (X_4), and oil yield (X_5) which showed significant correlation with seed yield were involved in formulating selection indices. The formulation of selection index for oil yield also involved five significantly correlated characters viz., plant height (X_1), head diameter (X_2), weight of head (X_3), number of filled seeds (X_4) and seed yield (X_5). Selection indices were formulated using the discriminant function as described by Smith (1936), while the genetic advance and relative efficiency of the indices were estimated according to the formulae given by Robinson *et al.* (1951) and Brim *et al.* (1959).

RESULTS AND DISCUSSION

Based on the nature of relationship, the characters could be grouped into growth characters; plant height (HT), yield components; head diameter (HD), weight of head (HW), number of filled seeds (FS), and yield characters, seed yield (SY) and oil yield per plant (OYP). The genotypic coefficient of variation, expected genetic advance (GA) and correlations (r) for seed yield and oil yield per plant is given in Table 1. The different selection indices formulated involving different combinations of characters along with estimated

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Table 1 . Genotypic coefficient of variation (GCV), expected genetic adance (GA) and correlations (r) in the sunflower germplasm for seed yield (SY) and oil yield per plant (OYP*).

S.No.	Characters	GCV (%)	GA (%)	r (SY)	r (OYP) *
1.	HT	19.64	39.78	0.8506 **	0.7091 **
2.	HD	16.67	22.44	0.7722 **	0.7418 **
3.	HW	51.09	71.06	0.8312 **	0.7148 **
4.	FS	30.62	40.67	0.9112 **	0.8090 **
5.	SY/OYP *	35.99	50.47	0.8819 **	0.8819 **

HT = Plant height
HD = Head diameter
HW = Weight of head
FS = Number of filled seeds
SY = Seed yield
OYP = Oil yield per plant

values of genetic advance and relative efficiencies of those indices over the straight selection for seed yield and oil yield per plant are given in Table 2. It was clear that maximum relative efficiency was observed in the growth character HT followed by yield component FS for both Seed yield and Oil yield per plant. Similar results have been reported by Asawa *et al.* (1977) to carry out selection with HT and FS as the combination of two character indices. On the contrary, the relative efficiency of HT and HD was observed to be maximum by Chaudhary and Anand (1985).

Four indices involving two characters were more efficient compared to straight selection for seed yield and oil yield. Six indices involving three characters were more efficient when compared to selection for either Seed yield or Oil yield per plant. One index containing the four characters viz., plant height, head diameter, weight of head and number of filled seeds showed maximum relative efficiency (120%) which are mostly the yield components.

Naskar *et al.* (1982) suggested plant height, leaf area, leaf area index, head diameter and per cent seed set as components of the selection index for seed yield in sunflower. Selection index consisting of plant height, head diameter, seeds per capitulum and leaf number was recommended by Lakshmanaiah (1980). The combination of leaf area, test weight, head diameter and plant height as characters of selection index were suggested by Seshagiri Rao (1989). However, for a plant breeder, a selection index with minimum number of characters is preferable to the ones with more number of characters unless those are distinctly superior to the indices involving less number of characters. The present study points to the presence of HT and/or FS in all the selection indices which were superior to straight selection for yield.

From the above results, it would be reasonable to suggest that a breeder engaged in the improvement of sunflower yield and oil yield should lay greater emphasis on HT and FS as the combination of characters in formulating selection indices.

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Table 2 . Selection indices, genetic gain (GA) expected from them and their relative efficiency (RE) as compared to straight selection for seed yield and oil yield in sunflower accessions.

S.No.	Combinations	Genetic gain (SY)	Genetic gain (OYP*)	Relative efficiency (SY)	Relative coefficiency (OYP*)
1.	X_6 Seed yeild per plant/ oil yield per plant*	15.2193	4.1793	100.00	100.0000
2.	X_1 Plant height	17.4565	4.3157	114.7002	103.2652
3.	X_2 Head diameter	11.1415	2.9870	73.2062	71.4726
4.	X_3 Weight of head	12.4015	2.9768	81.4856	71.2272
5.	X_4 Number of filled seeds	12.8529	3.1843	84.4513	76.1988
6.	X_5 Oil yield per plant*/ Seed yield per plant	13.2052	3.7461	86.7664	89.6363
7.	X_1 + X2	17.5052	4.3582	115.0202	104.2828
8.	X1 + X3	17.8821	4.3994	117.4962	105.2685
9.	X1 + X4	18.1259	4.4834	119.0986	107.2768
10.	X1 + X5	18.2177	4.5948	119.2177	109.9422
11.	X2 + X3	12.8244	3.2211	84.2641	77.0736
12.	X2 + X4	13.5349	3.4531	88.9325	82.6256
13.	X2 + X5	13.6894	3.8042	89.9478	91.0266
14.	X3 + X4	13.9604	3.4122	91.7284	81.6464
15.	X3 + X5	14.1427	3.7678	92.9260	90.1551
16.	X4 + X5	13.7660	3.7860	90.4132	90.5908
17.	X1 + X2 + X3	17.9247	4.4012	117.7764	105.3111
18.	X1 + X2 + X4	18.1531	4.4839	119.2773	107.2896
19.	X1 + X2 + X5	18.2721	4.5998	120.0589	110.0616
20.	X1 + X3 + X4	18.1960	4.4914	119.5592	107.4681
21.	X1 + X3 + X5	18.2676	4.5964	120.0296	109.9814
22.	X1 + X4 + X5	18.2858	4.5955	120.1488	109.9592
23.	X2 + X3 + X5	14.1901	3.8060	93.3380	91.0688
24.	X2 + X4 + X5	14.0511	3.8052	92.3245	91.0498
25.	X3 + X4 + X5	14.0511	3.8052	92.3245	91.0498
26.	X1 + X2 + X3 + X4	18.3038	4.4918	120.2669	107.4794
27.	X1 + X2 + X3 + X5	18.4083	4.5999	120.9539	110.0650
28.	X1 + X2 + X4 + X5	18.3627	4.6002	120.6540	110.0715
29.	X1 + X3 + X4 + X5	18.3142	4.5970	120.3353	109.9952
30.	X2 + X2 + X3 + X5	14.4103	3.8070	94.6846	91.0938
31.	X1 + X2 + X3 + X4 + X5	18.46003	4.6003	121.3238	110.0745

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STABILITY ANALYSIS FOR SEED YIELD AND RELATED CHARACTERS IN SAFFLOWER (*Carthamus tinctorius* L.) HYBRIDS

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ABSTRACT

Nine safflower hybrids and three varieties were evaluated at eight locations for five parameters of stability. Results indicated significant variation in respect of g x e interaction for yield and five yield attributes. A large portion of this interaction was accounted for by the linear regression on the environmental means, although nonlinear component was also significant indicating the possibility of prediction across environments. Considering the mean performance over environment, the hybrids DSH-116, DSH-135 and variety A-1 were responsive and stable for yield. The hybrid DSH-128 was observed to be specially adapted to unfavorable (poor) environments, where as the hybrid MKH-11 was observed to be specifically adapted to favorable (rich) environment for seed yield. The hybrids DSH-113, DSH-116, DSH-130 and released variety HUS-305 were well adapted and stable in all environments for oil content.

Key words : Stability, g x e interaction, safflower hybrids.

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is an important rabi oilseed crop of India. The productivity of this crop has improved by more than two-fold during the last three decades. Although breeding efforts initiated since early 70's resulted in the identification and development of several high yielding varieties of specific regional and multiregional importance (Ranga Rao, 1984), none of the varieties could out yield which was released in 1969. In the absence of cytoplasmic-genetic male sterility system, the genetic male sterility system has been used to commercially exploit heterosis for the development of hybrids in safflower. Some of the hybrids have shown upto 50% superiority in oil yield over the national check A-1 (DOR, 1994). For hybrids to become popular, it is necessary that apart from their superior productivity levels, they must also possess high degree of adaptability. Hybrids are known to have better homeostatic mechanism and more tolerance to soil and atmospheric stress in several crops and the same can be expected in safflower as well (Rao, 1989). In the present studies, stability analysis for seed yield and related characters has been carried out in nine hybrids and three varieties of safflower under irrigated condition.

MATERIALS AND METHODS

Genetic male sterility based nine hybrids with three check varieties were evaluated at eight locations viz., Annigeri, Phaltan, Raichur, Bheemarayanagudi, Jalna, Parbhani, DOR, Hyderabad and Raipur during rabi 1994-95. They were evaluated in randomised block design with three replications in a net plot size of 1.8m x 4.6 m. The spacing adopted was 45 x 20 cm. Recommended package of practices and plant protection measures were followed to raise a healthy crop. The observations were recorded on

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of stability as per the method of Eberhart and Russel (1996). The coefficient of determination (r^2) and Ecovalnce (Wi) were computed following Becker (1981) and Bilbro and Ray (1976). The significance of regression coefficient was tested by 't' test.

RESULTS AND DISCUSSION

Pooled analysis of variance revealed the existence of significant genetic differences among the genotypes for all the traits (Table 1). The environments also appeared to be significantly different from one another as the mean square component due to environment was highly significant. This indicated that the genotypes and the environments were significantly diverse. The mean square due to environment plus genotype x environments were significant for all the traits. The g x e interaction for all the characters indicated that genotypes interacted strongly with environment. The g x e interaction was further partitioned into linear and nonlinear components. since, linear and nonlinear components were significant, practical usefulness of predication would depend on relative magnitude of two variances. In the present study, linear component played an important role in the expression of these characters because, the linear component was larger in magnitude than nonlinear indicating that the performance of genotypes may be predicted across the environments. In prediction of performance, the nonlinear component may have a role, since it is also significant. Thus, the present findings are in consonance with those of earlier workers like Patra (1976), Ehadale *et al.* (1977), Rao and Ramachandram (1979), Narkhede *et al.* (1984), Patil *et al.* (1992) and Parmeshwarappa *et al.*(1993).

The coefficient of determination provides measures of variation (Bilbro and Ray, 1976) and ecovalence measures the contribution of each generally depends on the magnitude of the deviation mean squares, for the components which is due to linear regression, is usually small. Thus, in addition to three parameters viz., mean performance (x), regression coefficient (bi) and deviation from regression ($\bar{S}^2$ di); two other parameters viz., coefficient of determination (r^2) and ecovalence (Wi) were also considered as the parameters of stability. Accordingly, an ideal adaptable genotype is one having unit regression coefficient and coefficient of determination and least or zero value of ecovalence and deviation from regression. All five parameters of stability for different traits are presented in Table 2.

In case of seed yield, almost all the genotypes except local check had significance for linear component of g x e interaction and only four genotypes had significance for nonlinear g x e interaction, indicating thereby the predominance of linear component of g x e interaction suggesting possibility of prediction for this trait across locations. Considering the individual parameter of stability, it becomes evident that the hybrids viz., DSH-135, DSH-116 and variety A-1 were most responsive and possess average stability for yield. The hybrids MKH-11 possesses below average stability whereas, the hybrid DSH-128 possesses above average stability.

In case of oil content, ten genotypes were significant for linear component and only two genotypes were significant for nonlinear component of g x e interaction in the inheritance of this trait, as was also reported by Ranga Rao and Ramachandram (1979) and Parmeshwarappa *et al.*, (1993). Considering the mean performance and stability parameters, the hybrids viz., DSH-113, DSH-116, DSH-130 and variety HUS-305 were found stable, as they had bi values around unity and least nonsignificant $\bar{S}^2$ di values. Their mean oil content was found to be higher than the variety HUS-305 except DSH-130. The hybrid

The hybrid DSH-107 recorded high mean oil content but it was unstable. The variety HUS-305 could be utilized as a genetic stock to combine stability for high oil content.

In case of test weight, ten genotypes were significant for linear component and five genotypes were significant for nonlinear component indicating thereby the predominance of linear component of gxe interaction for this trait. A perusal of stability indicated that the hybrids viz., DSH-113, DSH-129, DSH-130 and DSH-135 were more responsive and possess average stability.

In case of number of capitula/plant, all the genotypes were significant for linear component, while only two genotypes were significant for nonlinear component of g x e interaction suggesting preponderance of linear g x e interaction in the inheritance of this trait. Examination of individual parameters of stability revealed that the hybrids DSH-128, DSH-130, MKH-11 and variety A-1 were more responsive and possess average stability. The hybrid DSH-116 was responsive and possess above average stability where as the hybrid DSH-135 was responsive and expresses below average stability.

In case of days to flower, all the 12 genotypes were significant for linear component while five were significant for nonlinear component of g x e interaction, indicating thereby that for most of the genotypes g x e interaction was linear in nature, indicating possibility of prediction across the environments. Considering the individual parameters of stability, it is evident that the hybrids DSH-110, DSH-130, DSH-135 and MKH-11 and check variety A-1 were found responsive and stable for days to flower.

In case of days to maturity, all the 12 genotypes were significant for linear component On examination of individual parameters of stability, it is evident that the hybrids DSH-107, DSH-128 and MKH-11 and check variety A-1 were observed to be most responsive and stable. However, the hybrid DSH-130 was below average in response and stability.

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	d.f.	Days to flower	Days to maturity	Capitula/ plant	100 seed wt. (g)	Seed yield (q/ha)	Oil content (%)
Genotypes	11	34.89 **	15.03 *	33.67 *	5.91 **	28.34 *	49.89
Environments	7	2354.77 *	1356.28 **	3032.79 **	3.88 **	617.32 **	15.10 **
G X E	77	8.618 *	6.91 *	27.22 *	0.43 **	9.50 *	5.47 **
Environment (G X E)	84	204.10 **	122.47 **	277.68 **	0.72 **	58.33 **	6.27 **
Environment Linear	1	16499.16 **	9489.63 **	21221.02 **	27.33 **	4320.00 **	1.89 *
G X E Linear	11	12.00 *	8.32 *	164.37 **	0.63 **	17.67 **	10.07 **
Pooled deviation	72	8.74 *	10.30 *	6.58	0.37 **	5.66	35.19 **
Pooled error	176	3.02	2.68	2.28	0.11	8.56	0.49

*, ** significant at 5% & 1% level respectively.

Table 2 . Estimates of stability parameters for different traits in safflower *hybrids*.

Hybrids	Seed yield (q/ha)					Oil content (%)				
	$\bar{X}$	bi	$\bar{S}^2di$	r^2	Wi	$\bar{X}$	bi	$\bar{S}^2di$	r^2	Wi
1	2	3	4	5	6	7	8	9	10	11
DSH-113	18.21	1.1739 **	-2.80	0.9377	10.32	34.45	1.02	-0.685	0.9455	0.007
DSH-107	16.79	1.2796 **	2.32	0.9002	28.32	32.38	0.57	0.010	0.7064	1.690
DSH-110	18.06	1.1779 **	-4.58	0.9544	11.24	29.88	1.04	76.90 **	0.0033	27.580
DSH-116	17.60	0.9554 **	-0.29	0.9277	0.70	30.47	0.95 *	0.260	0.9008	0.034
DSH-128	19.58	0.7050 *	1.30	0.8043	31.44	27.28	0.63	0.900	0.4168	1.350
DSH-129	19.91	0.8469 *	5.17 *	0.6270	8.51	26.85	1.38 **	5.770	0.7419	2.313
DSH-130	20.13	1.1529 **	-7.63 *	0.9885	0.23	26.20	0.95 *	-0.020	0.9568	0.086
DSH-135	16.59	0.9888 **	1.65	0.8947	0.04	30.80	1.32 **	0.520	9.9057	0.470
MKH-11	20.18	1.2188 **	0.09	0.9625	0.47	28.81	1.41 *	7.410	0.5625	2.852
A-1	17.92	0.9213 *	0.98	0.7437	2.23	26.46	0.99 *	6.010	0.2676	0.001
HUS-305	14.16	0.9159 **	7.20 *	0.6763	10.42	30.21	0.90 *	1.072	0.0054	0.104
Local check	15.72	0.6159 *	6.31 *	0.5760	9.43	25.40	1.10 *	17.55 **	0.0410	3.390
Mean	17.90	1.0001				29.43	1.002			
SEm ±	0.8998	0.1254								

Table 2 continued........

Hybrids	Test weight (g)					No. of capitula/plant				
	$\bar{X}$	bi	$\bar{S}^2di$	r^2	Wi	$\bar{X}$	bi	$\bar{S}^2di$	r^2	Wi
	12	13	14	15	16	17	18	19	20	21
DSH-113	4.50	1.0204 **	0.0716	0.9635	0.0011	21	0.85 *	0.7299	0.6859	38.74
DSH-107	4.35	0.3497	1.0803 **	0.0401	1.4269	19	1.12 **	3.5468 *	0.6844	124.82
DSH-110	4.98	1.1293 **	0.4872 *	0.4820	0.0464	23	1.33 **	0.5369	0.9945	186.83
DSH-116	5.23	0.1243	0.0491	0.0643	1.7968	20	0.73 *	1.0431	0.9791	09.05
DSH-128	6.13	0.8284 *	0.3022 *	0.4363	0.0764	23	1.03 **	-0.1984	0.9944	01.46
DSH-129	7.09	0.9766 *	0.0552	0.9285	0.0403	22	0.74 *	0.0609	0.9857	117.73
DSH-130	6.77	1.0293 **	0.1897	0.6413	0.0021	26	0.92 **	0.9641	0.9917	04.01
DSH-135	5.27	0.9183 *	0.0890	0.9193	0.0159	20	1.32 **	1.1242	0.9866	0.43
MKH-11	5.65	1.0225 **	0.0639	0.7988	0.0012	23	1.02 **	1.0224	0.9868	1.00
A-1	6.26	2.2705 **	0.3674 *	0.8298	4.2959	20	0.97 *	0.0565	0.9648	04.77
HUS-305	4.92	1.3570 **	0.1948	0.7525	0.3172	19	0.64 *	4.6730 *	0.6758	233.77
Local check	5.63	1.0346 *	0.4929 *	0.4645	2.7504	22	0.92 *	2.9501	0.4578	25.75
Mean	5.56	0.9967				22	0.9995			
SEm ±	0.2284	0.3990				0.96	0.0609			

Table 2 continued........

Hybrids	Days to flower					Days to maturity				
	$\bar{X}$	bi	$\bar{S}^2di$	r^2	Wi	$\bar{X}$	bi	$\bar{S}^2di$	r^2	Wi
	22	23	24	25	26	27	28	29	30	31
DSH-113	80	1.05 **	34.41 *	0.6775	3.781	129	0.98 **	48.06 **	0.7240	10.088
DSH-107	78	0.93 **	48.41 *	0.9632	5.688	128	1.04 **	1.08	0.9230	1.777
DSH-110	78	0.96 **	5.63	0.9792	2.766	129	1.07 **	12.90 *	0.9755	4.706
DSH-116	78	0.95 **	25.08 *	0.9797	3.184	130	0.96 **	5.51	0.9495	1.274
DSH-128	80	1.03 **	5.93	0.9953	1.264	131	1.06 **	1.37	0.9849	3.538
DSH-129	79	0.92 **	8.39	0.9922	8.345	130	1.14 *	13.44 *	0.9752	15.844
DSH-130	81	1.00 **	5.83	0.9953	1.264	131	1.06 **	1.37	0.9849	3.538
DSH-135	82	0.99 **	2.20	0.9628	0.008	132	1.01 **	5.69	0.9574	0.168
MKH-11	81	0.98 **	1.01	0.9451	0.289	131	0.95 **	4.31	0.9578	1.954
A-1	84	1.07 **	4.84	0.9821	0.707	133	0.98 **	4.80	0.9475	0.161
HUS-305	82	1.06 **	25.30 *	0.5831	3.321	131	0.96 **	12.98 *	0.6689	7.244
Local check	83	1.01 **	30.40 *	0.3829	7.400	132	0.90 *	17.90 *	0.6070	8.950
Mean	80	3.9974				130	1.002			
SEm ±	1.175	0.0795				1.213	0.114			

*, ** significant at 5 % and 1 % level respectively.

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COMBINING ABILITY AND HETEROSIS STUDIES IN CASTOR (*Ricinus communis* L.)

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ABSTRACT

Combining ability and heterosis studies were attempted in parents and hybrids made in a line x tester design in castor genotypes. The results indicated predominance of additive gene action for agronomic characters and non-additive gene-action for seed yield and oil content. The parents with good general combining ability for various characters and hybrids with desirable specific combining ability were identified. Significant better parent heterosis for number of nodes up to main spike indicating earliness was expressed by majority of the crosses. Few crosses were superior yielders over the respective better parents. The high heterosis for seed yield was associated with number of effective spikes per plant.

KEYWORDS : Combining ability, gene action, heterosis, castor.

INTRODUCTION

India is the first country in the world to exploit hybrid vigour in castor crop commercially. However, till recently research efforts were not on intensive improvement of the crop in particular and hybrid breeding in general. Development of hybrids involves improvement of pistillate base and development of superior monoecious combiners. A number of new pistillate lines were developed either through conventional or mutation breeding. On the other hand some new monoecious lines were also developed. An attempt has been made to study the combining ability of new pistillate and monoecious lines and heterosis of hybrid for seed yield, oil content and other agronomic characters.

MATERIALS AND METHODS

Four pistillate lines of castor developed from gamma-ray irradiated VP-1 mutants were crossed with five male parents in a line x tester mating design. The morphological details of the parents are presented in Table 1. The twenty hybrids and the parental lines were sown in contiguous blocks in a Randomised Block Design with three replications. A net plot size of 2 rows of 5.4m length with a spacing of 60 cm between the rows and 45 cm between the plants was maintained. The experiment was conducted under rainfed situations following recommended agronomic practices and plant protection measures.

The data were recorded for number of nodes up to primary, first secondary and second secondary racemes, plant height up to primary raceme, total and effective length of primary spike, capsule number in primary raceme, effective number of spikes per plant, seed yield per plant at 120, 150 and 180 days after sowing, 100 seed weight and oil content.

Analysis of variance was carried out both in respect of parents and hybrids on plot mean basis for each character following the procedure Presented by Kempthorne (1957) and detailed in Arunachalam (1974). The better parent heterosis (heterobeltiosis) was calculated and tested using t-test.

RESULTS AND DISCUSSION

The analyses of variance (Table 2) indicated that the parents, males and females were different among themselves for almost all the characters

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studied. However, the females did not show significant differences for plant height up to primary raceme and seed yield per plant up to 180 days after sowing. The values of gca and sca variances revealed that σ^2 gca is higher except oil content and seed yield upto 150 days of picking for which σ^2 sca was higher. This indicated that additive gene action was involved for all the characters only, oil content and seed yield at mid growth stage were governed by non-additive gene action. Among the female parents (Table 3) M-568 was a better general combiner for effective length of primary raceme, number of capsules in primary raceme and seed yield at 150 days of picking; M-591 was better general combiner for number of nodes upto secondary raceme-1, while M-619 was superior general combiner for seed yield at early pickings, 100 seed weight and oil content. M-584 did not show any significant gca effect for any of the traits studied.

Among the male parents, REC-2 and REC-6 were good general combiners for earliness as gca effects for number of nodest up to primary and secondary racemes were significant in desirable direction. The genotypes DCS-9 and 48-1 had higher gca values for seed yield up to later pickings and early pickings, respectively. Besides, 48-1 was a good combiner for seed boldness and oil content. RMC-3 had better combining ability for total and effective length of primary spike and seed boldness.

In general, the hybrids did not show superior combining ability effects for a number of traits (Table 4). DCH-169 was good specific combiner for earliness, while DCH-171 was good combiner for late flowering in secondary spikes. None of the hybrids was good combiner for total and effective length of primary raceme. DCH-158, DCH-164 and DCH-171 were better combinations for more no. of capsules in the primary raceme, while DCH-155, DCH-159 and DCH-171 were good combinations for no. of effective spikes per plant. DCH-162 and DCH-160 were better combinations for 100 seed weight and oil content, respectively. For seed yield, although none of the hybrids had significant sca values DCH-157, DCH-163 and DCH-171 were better combinations. DCH-171 showed significant sca values for seed yield and yield attributing characters, namely, number of effective spikes per plant and number of capsules in the primary raceme.

A good number of hybrids showed significant BP heterosis for earliness in flowering time in primary spike and early spike orders. None of the hybrids showed any BP heterosis for total and effective length of primary raceme, capsule number in primary raceme, 100 seed weight and seed yield from late order spikes. While DCH-154 and DCH-161 showed positive significant BP heterosis (122 and 40.33%, respectively) for plant height upto primary raceme, DCH-157 had less plant height upto primary raceme with a BP heterosis of 37.47%. DCH-159 and DCH-171 had 55.46 and 26.72% heterosis, respectively for number of effective spikes per plant. DCH-169 and DCH-171 also showed significant heterosis for oil content. BP heterosis for seed yield ranged from -13.66% to 89.86% in the early growth stages. All the hybrids except DCH-154, DCH-157, DCH-164 and DCH-171 had negative BP heterosis (non-significant). Significant BP heterosis for seed yield ranged from 25.79% to 89.86% at early pickings indicating that some of the early flowering hybrids are significantly higher yielders at early picking only.

The differences for seed yield and yield attributing characters among the female parents were due to mutation of VP-1 under gamma ray irradiation and subsequent selection in desirable direction. The pistillateness in the parents is the most crucial to use them in the large scale hybrid seed production.

The gene action analysis clearly indicated the usefulness of hybrid breeding for higher seed

Table 1. Pedigree and morphological characters of the parents used in crossing

Line	Pedigree	Morphological characters
Females		
1. M-568	Gamma -ray (55 kr)	G 2 Sp
2. M-584	—do—	G 3 Sp
3. M-591	—do—	R 3 Sp
4. M-619	—do—	G 3 Sp
Males		
1. REC-2	Bhagya X CO-1	R 2 Sp
2. REC-6	240 X Bhagya	R 2 Nsp
3. DCS-9	240 X Bhagya	R 2 Sp
4. RMC-3	Bhagya X HC-8	R 3 Sp
5. 48-1	HO x MD	R 2 Nsp

G.R. : green, red stem; 2,3: double, triple bloom;
Sp, Nsp: spiny, non-spiny capsules

yield and oil content. Since the other characters are governed by additive genes, those could be improved by a well designed pedigree selection procedure. Similar results have been reported by Patel *et al.* (1984), Bhatt and Reddy (1986), Patel *et al.* (1989), Dangaria *et al.* (1987), Fatteh *et al.* (1988), Pathak *et al.* (1989). Oil content has also been reported to be governed by non-additive gene action (Fatteh *et al.*, 1987; Dobaria *et al.* 1989).

A distinct and positive heterosis for flowering time was exhibited by almost all the hybrids. As reported by Ankineedu and Kulkarni (1967), Patel *et al.* (1984). The hybrids DCH-159 and DCH-171 offered higher seed yield, which could be attributed to more number of effective spikes per plant (Table 3). Early flowering hybrids have a definite place in rainfed agriculture under situations like rice- fallow with residual moisture and minimum tillage. Some of these hybrids also showed superior yielding ability over GCH-4/ DCH-30 in multilocation evaluation trials of AICORPO (Castor) in rainfed and irrigated situations (AICORPO, 1995). The study indicated that seed and oil yield could be improved through hybridization of two improved lines i.e., pistillate and monoecious lines in castor. The characters could be improved through selection of progenies derived from a cross involving higher perse performance.

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Table 2 . Anova for seed yield and agronomic traits in castor.

Source	df	NPS	NSR-1	NSR-2	HPR	TLPR	ELPR	NCPR	NESP	HSW	OILC	SY120	SY150	SY180
Parents	8	16.87 **	2.91 **	4.63 **	2085.73 **	170.61 **	131.35 **	434.75 **	32.03 **	85.80 **	15.54 **	1174464 **	46053 **	12773 **
Hybrids	19	6.58 **	0.47 **	0.81 **	1141.03 **	49.45 *	61.59 **	458.21 **	10.24 **	22.50 **	2.94 *	76139 **	15342 **	11461 **
Females(F)	3	0.58	0.42 **	0.40 *	21.18	90.45 *	157.61 **	316.03 **	17.04 **	18.47 **	5.06 *	104720 **	26075 **	6240
Males (M)	4	28.59 **	1.62 **	2.87 **	4833.85 **	120.48 **	122.67 **	1609.30 **	18.13 **	75.68 **	2.85	256569 **	24502 **	25805 **
F X M	12	0.74	0.11 **	0.23	190.05	15.53	17.23	110.06	5.91	5.79	2.46	8851	9606 *	7984 **
Error	38	0.40	0.08	0.10	178.22	24.92	18.33	34.75	4.31	4.28	1.57	11641	4132	2947
σ^2 gca		1.03	0.068	0.104	165.73	6.6624	9.1042	63.15	0.86	3.06	0.11	12725	1162	2382
σ^2 sca		0.11	0.006	0.043	3.94	@	@	25.10	0.533	0.50	0.29	@	1825	1679

NPS : no. of nodes to pr. spike; NRS-1; no of nodes to first secondary spike; NSR-2; no. of to second secondary spike;
HPR : height upto pr. racene; TLPR : total length of primary raceme; ELPR : effective length of primary raceme; NCPR : no. of capsules in pr. raceme;
NESP : No. of effective spikes per plant; HSW : 100 seed weight; OILC : oil content; SY 120, SY 150, SY 180 : seed yield upto 120, 150, 180 days after Sowing; @ : negative estimates

Table 3 . **GCA effects of parents for yield and other agronomic traits in castor.**

Source	NPS	NSR-1	NSR-2	HPR	TLPR	ELPR	NCPR	NESP	HSW	OILC	SY120	SY150	SY180
Females													
M-568	-0.12	0.18	0.20	-0.90	1.72	4.18 *	6.39 *	0.90	-0.26	0.09	-6.97	40.92 *	5.50
M-584	-0.17	0.05	0.07	0.71	1.46	0.83	-0.03	0.61	-0.53	-0.48	3.77	-28.75	4.77
M-591	0.27	-0.22 *	-0.13	-1.11	-3.58 *	-3.13	-4.22	-1.49	-0.83	-0.40	-100.57	-42.42	-29.03
M-619	0.02	-0.02	-0.13	1.30	0.40	-1.88	-2.15	-0.03	1.63 *	0.78 *	103.72 *	30.25	18.77
se(gi-gi)	0.23	1.06	0.12	4.87	1.82	1.56	2.15	0.75	0.75	0.45	39.39	23.47	19.82
Males													
REC-2	-0.33 *	-0.16	-0.15	-11.68 *	-0.33	1.74	-5.38	0.47	-3.73	-0.24	-51.32	-34.27	22.35
REC-6	-2.35 *	-0.53 *	-0.70 *	-27.72 *	-5.30	-5.06	-15.80	0.70	-1.25	0.13	-194.32	-46.10	-73.32
DCS-9	0.77 *	0.46 *	0.62 *	8.74	1.88	2.54 *	2.62	-0.26	0.68	-0.40	24.52	20.65	51.93 *
RMC-3	0.10	0.07	-0.02	6.40	2.71 *	2.04 *	2.99 *	-2.01	1.97 *	-0.25	10.35	-6.60	3.35
48-1	1.82 *	0.16 *	0.25 *	24.27	1.04	-1.26	15.56 *	1.11	2.32 *	0.79 *	210.77 *	66.32 *	-4.32
se(gi-gi)	0.25	1.19	0.13	5.45	2.03	1.74	2.40	0.84	0.84	0.51	44.04	26.24	22.16

See Table 2 for abreviated characters.

Table 4 . SCA for seed yield and agronomic traits in castor hybrids

Hybrids	Pedigree		NPS	NRS-2	HPR	NESP	OILC	SY120	SY150	SY180
DCH-154	M-568	X REC-2	0.13	0.15	15.33 *	-1.54	-0.19	25.0	29.6	53.6
DCH-155	-do-	X REC-6	-0.12	-0.30	-1.09	2.10 *	0.14	-6.6	-18.8	-67.1
DCH-156	-do-	X DCS-9	-0.10	-0.80 *	0.72	-0.94	0.61	-27.7	-13.9	-22.3
DCH-157	-do-	X RMC-3	0.03	0.42 *	-12.15 *	0.68	-0.21	-1.9	79.3 *	57.6 *
DCH-158	-do-	X 48-1	0.05	-0.18	-2.82	-0.31	-0.35	11.3	-76.2	-21.7
DCH-159	M-584	X REC-2	-0.35	-0.12	-9.88	1.95 *	-0.95	-32.3	-10.3	-8.7
DCH-160	-do-	X REC-6	0.27	-0.03	0.96	-0.60	1.45 *	22.6	21.8	10.9
DCH-161	-do-	X DCS-9	0.15	-0.05	7.30	-0.24	-1.05	70.1	-32.2	-12.3
DCH-162	-do-	X RMC-3	0.15	-0.32	7.84	-1.63	-0.37	26.3	-44.0	-45.0
DCH-163	-do-	X 48-1	-0.23	0.42 *	-6.23	0.52	0.92	-86.8	64.7 *	54.9 *
DCH-164	M-591	X REC-2	1.08 *	-0.18	-0.19	-0.08	0.60	17.3	16.3	2.1
DCH-165	-do-	X REC-6	-0.37	0.30	-0.58	0.20	-0.54	4.0	30.8	33.4
DCH-166	-do-	X DCS-9	-0.49	-0.15	-3.81	-0.88	0.36	-97.5	-30.2	-43.8
DCH-167	-do-	X RMC-3	-0.15	0.15	1.39	0.61	-0.52	16.6	18.7	-9.2
DCH-168	-do-	X 48-1	-0.07	-0.12	3.19	0.56	0.10	59.6	-35.6	17.4
DCH-169	M-619	X REC-2	-0.87 *	0.15	-5.27	-0.34	0.55	-10.0	-35.7	-47.0
DCH-170	-do-	XREC-6	0.22	0.03	0.71	-1.30	-1.05	-20.0	-33.8	22.6
DCH-171	-do-	X DCS-9	0.43	0.18	-4.22	2.06 *	0.08	55.1	76.4 *	78.4 *
DCH-172	-do-	X RMC-3	-0.03	-0.25	2.92	0.35	1.10	-41.0	-54.0	-3.3
DCH-173	-do-	X 48-1	0.25	-0.12	5.85	-0.77	-0.68	15.9	47.1	-50.7
se (sij-skl)			0.52	0.31	10.90	1.69	1.02	88.1	52.5	44.3

See Table 2 for abbreviated characters

Table 5. Heterosis (BP) for seed and agronomic traits in castor hybrids.

Hybrids	Pedigree		NPS	NRS-2	HPR	NESP	OILC	SY120	SY150	SY180
DCH-154	M-568	X REC-2	-10.2 *	27.2 *	122.3 *	24.6	2.20	89.9 *	47.5	31.4
DCH-155	-do-	X REC-6	-29.4 *	-41.8 *	6.2	30.0	1.00	16.2	5.5	-78.6
DCH-156	-do-	X DCS-9	-2.8	-19.4 *	25.9	3.1	3.51	3.2	-16.6	-20.1
DCH-157	-do-	X RMC-3	-8.9	-21.4 *	-37.5 *	13.7	2.20	-3.1	76.2 *	23.7
DCH-158	-do-	X 48-1	-8.7 *	26.2 *	-13.1	-31.5	-0.26	11.6	-54.7	-28.6
DCH-159	M-584	X REC-2	-16.1	27.4 *	24.4	55.5 *	-0.55	70.9 *	-4.7	-37.1
DCH-160	-do-	X REC-6	-27.8 *	-34.7 *	9.0	0.0	2.48	25.8	-11.7	-61.6
DCH-161	-do-	X DCS-9	-2.8	-12.6 *	40.3 *	7.6	-1.77	19.8	-46.0	-28.8
DCH-162	-do-	X RMC-3	-8.3	-28.4 *	-13.5	-21.0	0.00	2.3	-31.6	-54.9
DCH-163	-do-	X 48-1	-11.1	-12.6 *	-15.0	-28.2	1.12	0.8	-40.8	-25.2
DCH-164	M-591	X REC-2	-10.1 *	17.7 *	45.5	28.1	2.82	89.4 *	-17.7	19.7
DCH-165	-do-	X REC-6	-36.2 *	-19.0 *	-2.2	-17.0	-1.34	-3.9	-16.1	-16.7
DCH-166	-do-	X DCS-9	-13.6 *	-2.5	17.6	-23.6	2.70	-21.6	-49.9	-41.2
DCH-167	-do-	X RMC-3	-16.1 *	-8.9	-22.7	-17.9	1.18	-13.7	-4.3	-6.8
DCH-168	-do-	X 48-1	--6.7	-8.9	-7.1	-41.1	-0.33	6.0	-63.0	-26.5
DCH-169	M-619	X REC-2	-34.2 *	-38.6 *	13.4	46.9	4.51 *	58.9 *	15.4	-27.1
DCH-170	-do-	XREC-6	-40.5 *	-47.4 *	-10.7	-13.3	0.00	25.6	-9.7	-38.2
DCH-171	-do-	X DCS-9	-18.0 *	-28.1 *	21.1	26.7 *	3.14	32.7 *	10.0	22.9
DCH-172	-do-	X RMC-3	-25.7 *	-42.1 *	-18.3	-2.6	5.60 *	6.9	-4.3	-16.6
DCH-173	-do-	X 48-1	-12.2 *	-36.8 *	-1.8	-40.2	0.46	25.8 *	-32.7	-40.1
CD (5%)			1.09	0.56	21.85	3.28	2.04	168.9	99.6	91.7

See Table 2 for abbreviated characters

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INFLUENCE OF PHOSPHORUS AND *Rhizobium* ON YIELD ATTRIBUTES, YIELD AND NUTRIENT UPTAKE OF GROUNDNUT (*Arachis hypogaea* L.)

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ABSTRACT

A field experiment was conducted for years (Kharif 1992 and 1993) at IGAU, RARS, Raigarh (M.P.) to findout the optimum phosphorus level with and without *rhizobium* inoculation. The study revealed that the application of P_2O_5 significantly increased the number of pods per plant, SMK %, pod and haulm yield during both the years, while shelling per cent and 100 seed weight were significantly increased only during first year. All the yield attributes and yield increased significantly up to 60 Kg P_2O_5 ha^{-1}. On an average 60 kg P_2O_5 ha^{-1} produced 17.72 per cent and 58.97 per cent higher yield over 30 kg P_2O_5 ha^{-1} and control, respectively. *Rhizobium* inoculation showed significant effect on yield during both the years. On an average 8.23 per cent yield increase was observed with *rhizobium* inoculation over uninoculated control. Similar trend was also observed for nitrogen and phosphorus uptake in haulm and kernel.

Key words : *Rhizobium*, phosphorus, nitrogen and phosphorus uptake, groundnut.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the important oilseeds crops in India and in Eastern Madhya Pradesh. It is grown both under rainfed and irrigated conditions during *kharif* and summer seasons. The average yield of this crop is very low due to imbalanced application of nutrients. Among the various factors affecting its production, phosphorus plays an important role in enhancing the production and productivity of the crop. Secondly, being a legume, it requires small quantity of nitrogen at initial stages to fulfil the nitrogen demand of seedlings till *Rhizobia* are established on the roots. To improve the effectiveness of *Rhizobia*, seed inoculation with *rhizobium* responds favorably in the formation of nodules on the roots as well as the fixation of atmospheric nitrogen. In this context, the information is scanty for the Inceptisols of the Eastern Madhya Pradesh. Therefore, in the present study, an attempt has been made to assess the effect of different levels of phosphorus and *rhizobium* inoculation on the yield components and nutrient uptake of groundnut in light textured Inceptisols.

MATERIALS AND METHODS

A field experiment was conducted during the rainy season of 1992 and 1993 in subtropical humid climatic conditions in the eastern Madhya Pradesh (21° 15' to 23°15' N latitude and 82°55' to 84°20' E longitude) at IGAU, Regional Agricultural Research Station, Raigarh (M.P.) The experimental soil was sandy loam and well drained having pH 6.1, organic carbon 0.35 per cent, low in available nitrogen and phosphorous (143.7 and 5.2 kg ha^{-1}) and medium in potassium content (257.0 kg ha^{-1}). The treatments consisted of four levels of phosphorus (0,30,60 and 90 kg P_2O_5 ha^{-1}) with and without inoculation. Inoculation of seeds was done by mixing *rhizobium* culture at the rate of 10 gm per kilogram of Kernels. The experiment was conducted with replications in a randomized block design. A uniform basal dose of 30 kg N and 30 kg K_20 ha-1 were applied at the time of field

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preparation. Entire quantity of P_2O_5 was drilled at the time of sowing according to treatment. The groundnut variety ICGS-11 was taken up as a test variety using seed @ 120 kg ha^{-1}. The crop was sown in rows 30 cm apart keeping 10 cm plant to plant spacing. All the recommended cultural practices were followed to raise the crop. Ten plants from each treatment were selected randomly for recording yield attributed. Pod yield was recorded from net plots and finally expressed in quintals per hectare. The nitrogen content was estimated by Kjeldahl method suggested by Chapman and Pratt (1961) and phosphorus content was analysed as described by Piper (1966). Shelling per cent and sound matured kernel per cent (S.M.K.%) were worked out as follows :

(i) $$\text{Shelling \%} = \frac{\text{Weight of kernels}}{\text{Weight of pods}} \times 100$$

(ii) $$\text{S.M.K.\%} = \frac{\text{No. of matured kernels}}{\text{Total no. of kernels}} \times 100$$

RESULTS AND DISCUSSION

Yield attributes and yield:

Application of phosphorus (Table 1) significantly increased the number of pods per plant, shelling per cent, S.M.K. %, 100 seed weight, haulm yield and pod yield (q/ha) during first year. Whereas, shelling % and 100 seed weight were at par with control during second year. All the yield attributes, haulm yield and pod yield increased significantly with every increment in phosphorus level up to 60 kg P_2O_5 ha^{-1}. On an average 60 kg P_2O_5 ha^{-1} produced 17.72 and 58.97 per cent higher yield over 30 kg P_2O_5 ha^{-1} was due to higher number of pods per plant, 100 seed weight, S.M.K. and shelling per cent which showed maximum utilization of applied Phosphorus at P_2O_5 ha^{-1} level.

Application of phosphorus in deficient soils increased concentration of P ions of soil solution, enhanced vigorous root development, nodule formation and nitrogen fixation and overall better development of plants, which ultimately resulted in increased yield attributes and yield. In low P containing soils, as in the case of present investigation, these parameters significantly increased with the application of medium dose of phosphorus. Since P plays an important role in root development and translocation of photosynthates and being the constituents of nucleic acid, phytin and phospholipid, its application increases different growth parameters. Differential response of P can be attributed to its uptake efficiency and its utilization which in turn is greatly influenced by environmental factors (Liggit and Greenfield, 1985). Similar findings were also reported by Singh and Ahuja (1985), Rao and Singh (1985), Deshmukh *ea al.* (1993), Mishra (1994) and Dimree and Dwivedi (1994).

Rhizobium inoculation showed significant effect only on S.M.K. per cent and pod yield during both the years (Table 1), while shelling per cent, 100 seed weight and haulm yield remained unaffected. On an average 8.23 per cent yield increase was observed with *rhizobium* inoculation over uninoculated control. Seed inoculation with *rhizobium* enhanced the nodulation and availability of free atmospheric nitrogen to the plant through symbiotic nitrogen fixation (Singh and Ahuja, 1985). Significant response of seed treatment with suitable *rhizobium* was also reported by Shasidhara *et al.* (1994). Bharambe *et al.* (1993) advocated that the use of *rhizobium* either as seed treatment or soil application significantly increased the pod yield of groundnut over control.

Nitrogen and phosphorus uptake :

Nitrogen and phosphorus uptake in haulm and kernel (Table 2) was significantly influenced by graded levels of phosphorus over control. These parameters increased significantly with every increment in phosphorus level up to 60 kg P_2O_5 ha^{-1}. But, application of 90 kg P_2O_5 ha^{-1} did not show significant response over 60 kg P_2O_5 ha^{-1} in relation to N and P uptake. However, the highest total N and P uptake were recorded with the application of 90 kg P_2O_5 ha^{-1}, while they were lowest in the control. Jana *et al.* (1990) also reported increased absorption of nitrogen and phosphorus with increase in phosphorus application rate from 0 to 52 kg P_2O_5 ha^{-1}. The increase in uptake of these nutrients in haulm and kernel was attributed to the increased root density and nodulation which enable the plants to extract more nutrients from the soil. (Nimje, 1992 and Singh *et al.*, 1994).

Nitrogen and phosphorus uptake (Table 2) in haulm and kernel were found significantly higher with *rhizobium* inoculation (seed treatment) than uninoculated control during both the years. Similar results were also reported by Shasidhara *et al.* (1994).

The results of the present investigation showed that application of 60 kg P_2O_5 ha^{-1} with *rhizobium* inoculation in groundnut crop grown in light textured Inceptisols of eastern Madhya Pradesh of central peninsular India was found beneficial for enhancing yield and nutrient uptake.

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Table 1 . Yield attributes and yield of groundnut as influenced by phosphorus and *rhizobium* inoculation.

Treatments	Shelling (%)			SMK (%)			100 seed wt. (g)			Pod yield (Q/ha)			Haulm yield (q/ha)		
	1992	1993	Mean	1992	1993	Mean	1992	1993	Mean	1992	1993	Mean	1992	1993	Mean
Phosphorus (kg/ha)															
0	58.2	63.0	60.6	87.2	86.3	86.8	26.8	24.4	25.6	13.9	9.5	11.7	30.4	21.5	25.9
30	60.4	63.1	61.7	88.6	87.8	88.2	27.5	24.9	26.2	18.8	12.8	15.8	38.6	26.8	32.7
60	61.0	64.3	62.6	90.8	89.4	90.1	27.9	25.8	26.9	22.4	14.9	18.6	44.2	30.3	37.2
90	62.4	64.9	63.6	91.4	90.2	90.8	28.0	25.7	26.9	23.6	14.2	18.9	45.8	30.8	38.3
SEm±	0.61	1.63		0.40	0.45		0.29	0.92		0.48	0.60		1.69	1.05	
CD (5%)	1.80	NS		1.20	1.32		0.86	NS		1.42	1.73		4.97	3.08	
Rhizobium															
Uninoculated	60.3	63.6	61.9	88.6	87.3	88.5	27.5	25.1	26.3	19.0	12.2	15.6	39.2	26.5	32.9
Inoculated	60.7	64.0	62.3	90.4	89.5	90.5	27.6	25.3	26.5	20.3	13.5	16.9	40.3	28.2	34.2
SE±	0.43	1.15		0.28	0.32		0.20	0.65		0.34	0.42		1.19	0.74	
CD (5%)	NS	NS		0.82	0.94		NS	NS		1.00	1.24		NS	NS	

Table 2 . Effect of phosphorus and *rhizobium* inoculation on N and P uptake in groundnut.

Treatments	Shelling (%)				SMK (%)			100 seed wt. (g)				Pod yield (Q/ha)				Haulm yield (q/ha)		
	1992	1993	Mean		1992	1993	Mean	1992		1993	Mean	1992	1993	Mean		1992	1993	Mean
Phosphorus (kg/ha)																		
0	42.9	32.0	37.5	26.9	19.6	23.3	69.8	51.6	60.7	9.7	6.7	8.2	5.5	3.7	4.6	15.2	10.4	12.8
30	61.0	44.5	52.7	39.3	28.3	33.8	100.3	72.8	86.5	19.3	13.6	16.5	9.3	7.1	8.2	28.6	20.7	24.7
60	76.5	54.5	65.5	52.5	37.4	44.9	129.0	91.9	110.5	28.7	18.2	23.4	15.3	11,7	13.5	44.0	29.9	36.9
90	81.5	56.7	69.1	57.5	36.7	47.1	139.0	93.4	116.2	31.1	19.8	25.5	17.4	12.0	14.7	48.5	31.8	40.2
SEm±	3.3	2.8		3.3	2.7		5.1	3.9		2.4	1.4		1.8	1.1		4.1	2.0	
CD (5%)	9.7	8.2		9.7	7.9		15.0	11.5		7.1	4.1		5.3	3.2		12.1	5.9	
Rhizobium																		
Uninoculated	61.8	43.8	52.8	40.2	27.2	33.7	102.0	71.0	86.5	19.5	12.8	16.2	9.6	7.4	8.5	28.6	20.2	24.7
Inoculated	69.1	49.9	59.5	47.8	33.8	42.8	116.9	83.7	100.3	24.9	16.4	20.6	14.2	9.8	12.0	39.6	26.2	32.6
SE±	2.3	2.0		2.3	1.9		3.6	2.8		1.7	1.0		1.3	0.8		2.9	1.4	
CD (5%)	6.8	5.9		6.8	5.6		10.6	8.2		5.0	2.9		3.8	2.3		8.5	4.1	

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EFFECT OF AGRONOMIC PRACTICES ON THE PERFORMANCE OF RAPESEED (*Brassica campestris*) AND INDIAN MUSTARD (*B.juncea*) VARIETIES IN POST-RICE SEASON OF COASTAL ORISSA

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ABSTRACT

In coastal Orissa, rapeseed and mustard were promising crops in rice fallows under irrigated situation. Rapeseed varieties viz., M-27, Toria T-9 and Toria Bhawani and Indian mustard varieties viz., Pusa Bold, Pusa Bahar, Pusa Basant, RH-30, Krishna and Varuna were found promising with seed yields of 0.9 and 1.8 t/ha respectively. Newly introduced hybrid mustard varieties showed potential with an yield of 1.5 t/ha and matured 15 days earlier than Varuna. Sowing Pusa Bold on 15 November resulted significantly higher yield over 25 October and 30 November. Higher response of irrigation was noticed with Pusa Bahar. Irrigating mustard twice along with 60 kg N/ha was ideal. The critical stages for irrigation were branching and flowering.

Key words : Rapeseed, Indian mustard, hybrid mustard, sowing date, moisture regime, siliqua development, seed yield.

INTRODUCTION

In Orissa, the area under mustard is 137.6 thousand hectares. However the seed yield of this crop is low (439 kg/ha) as against all India average yield (707 kg/ha). Two types of oil-yielding Brassica species are commonly grown in India and many other countries. Of these, Indian mustard (*Brassica juncea*) and Indian rapeseed (*B. campestris*) are important. Indian mustard has higher yield potential and shows a greater tolerance to moisture-stress as well as to diseases and pests. Indian rapeseed has several distinct groups of varieties, of which the brown-seeded types appear to have the largest production potential and are, therefore, grown over larger areas. Indian mustard is a recently introduced crop in Orissa because of its higher response to supplementary irrigation.

Most of the fields during post-rainy season (October to April) are left follow by the farmers derpite their scope for raising other crops after the harvest of rice However, possibilities exist to grow the crops of toria (*Brassica campestris*) and Indian mustard (*B. juncea*) varieties in rice fallows. Hence, the present study was taken up to find out the suitable promising toria mustard varieties and their agronomic requirement in post-rice season.

MATERIALS AND METHODS

Investigations were carried out at the Central Rice Research Institute. Cuttack during post-rainy season in rice fallows during 1990-1994. In all these years during *kharif* (June to September/October), rice varieties like Annada (105 days), Vandana (90 days) or Kalinga - III (85 days) were grown. The soils of experimental sites were sandy loam with pH 5.8-6.5 and organic carbon 0.3-0.5%. The water table fluctuated between 30 to 110 cm from October to March in each year in all the trials. The experiment wise materials and methods are described as below.

Varietal evaluation trials

During 1990-91 to 1993-94, 9 Indian mustard and 6 toria varieties were tested on-station (CRRI

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farm). An on-farm trial was also carried out at Bhairpur village (15 km from CRRI) under bunded upland with irrigation facility. Sowing was done during the first week of November in rows 30 cm apart with 60 kg N + 40 kg P_2O_5 + 40 kg K_2O/ha. Half of N along with full dose of P and K was applied in furrows at sowing and the rest half N was top dressed just before the first irrigation. Two irrigations of 5 cm depth were scheduled at one month intervals from the date of sowing. In all the trials, treatments were replicated thrice in a randomized block design.

Trial on sowing date, irrigation and varieties

During 1991-92, an experiment with three dates of sowing (25 October, 15 November and 30 November), two irrigation regimes (first at branching and second at flowering) and two mustard varieties (Pusa Bold and Pusa Bahar) was conducted. The treatments in this trial were replicated thrice in a split plot design. The dates of sowing were kept in the main plots and varieties x irrigation regimes in the sub-plots. The rainfall received during the crop growth was 162, 31 and 5 mm in October, November and December, respectively.

Trial on N and K_2O requirement

During 1993-94, a trial with four levels of nitrogen (0,30,60 and 90 kg/ha) and three levels of potassium (0,30 and 60 kg/ha) was conducted. The treatments were replicated thrice in a split-plot design. The N levels were maintained in main plots and K levels in sub-plots. The test variety was RH-30. Rainfall received was 157,33 and 5 mm in October, November and December, respectively. Nitrogen was applied in two equal splits each at sowing and flowering, while K was applied with first N application at sowing.

Trial on irrigation regime and N level

In an experiment conducted during 1988-89, three levels of N (0,30, and 60 kg N/ha and five irrigation regimes viz. I1 = Irrigated just after sowing, I2 = I1 + irrigation at branching, I3 = I1 + irrigation at flowering, I4 = I1 + irrigation at siliqua initiation, I5 = I1 + irrigation at siliqua development were tried in split-plot design with irrigation regimes in the main-plot and N levels in sub-plot. The mustard variety used was Pusa Bold. Half of N was given at sowing in furrows and the second dose of N at irrigation at branching.

Trials on irrigation, N levels viz., 30 and 60 kg/ha and 2 irrigation regimes was conducted with four toria and six Indian mustard varieties in a split-plot design. Toria varieties were; Toria T-9, TLC-1, Toria Bhawani and M-27 and Indian mustard varieties were; RLM 619, Varuna, Kranti, Krishna, Pusa Bold and Pusa Bahar. These varieties were sown on Nov. 1, 1991. First irrigation was given 25 days after sowing (at branching) and second one was given 15 days after the first irrigation in toria varieties and another 15 days later in Indian mustard varieties corresponding to flowering in each case.

In another trial conducted during 1992-93, three N levels (0,30 and 60 kg/ha) with two Indian mustard varieties (Pusa Bold and Pusa Bahar) were investigated under four moisture regimes viz., residual moisture (no irrigation), 1 irrigation at 35 days after sowing (DAS), 2 irrigations at 25 and 50 DAS and 3 irrigations at 25, 50 and 70 DAS.

Crop was protected against aphids by spraying with 0.025% phosphemidon mixed with water @ 600 - 800 litres/ha. The crop was harvested when the siliqua were golden yellow and were not fully ripened.

RESULTS AND DISCUSSION

Trial on varietal evaluation

Among the varieties tested in different years, the variety Pusa Bold gave the highest yield followed by Pusa Basant. Varieties Pusa Bahar and Krishna also produced comparable seed yields. Pusa Bahar and Gujarat M-1 matured within shortest period (108 days). Among the toria group, Toria T-9 gave significantly higher yield compared with Toria Bhawani or standard check variety, M-27 (Table 1). On-farm varietal evaluation trials showed a good scope for growing hybrid mustard yielding 1.4 to 1.5 t/ha seed yield within 80 days duration.

Effect of sowing date

Under rainfed situation the second fortnight of October was found to be the optimum sowing period. any delay beyond 25 October resulted in significant reduction in seed yield (Table 2) as early own crop could utilize better the residual soil moisture. Under irrigated situation, sowing during the first fortnight of November gave higher seed yield than early sowing (25 October) or late sowing (30 November). Variety Pusa Bahar gave significantly higher yield than Pusa Bold when sown under residual moisture at each dates. The Crop performance was superior when sown on 15 November, which gave 22 and 24% increase in yield over 25 October and 30 November showings, respectively. This increase in seed yield was due to the low temperatures (20-22°C) prevailed during the 15 November sowing, which is one of the favourable weather component for a good crop of mustard. Irrigating the crop twice increased the seed yield substantially over the crop grown under residual moisture. Saini (1984) reported that at Ludhiana each fortnight delay in sowing beyond 1 October resulted in 11.7, 33.5, 51.3 and 66.0 decrease in yield compared with 1 October sowing. Delay in sowing beyond November 18 significantly reduced yield attributes and seed yield by 38 per cent (Samui *et al.* 1995).

Effect of N and K_2O

The crop responded to application of nitrogen upto 60 kg/ha, beyond which the yield did not increase significantly, whereas the crop responded to K_2O application upto 60 kg K_2O/ha. Though the NxK interaction was not significant, but when the crop was fertilized with 120 kg N and 60 kg K2O/ha the seed yield was increased to the extent of 17% over same level of K with 60 kg N/ha (Table 3). Application of 60 kg N and 30 kg K2O/ha produced higher quantity of mustard oil (34.1%) as compared to other fertilizer treatments. Similar trends of increased seed yield of mustard with increasing level of N have also been reported by Saini (1984) and Rajput (1985).

Effect of irrigation

Increasing number of irrigations progressively increased the yield of Pusa Bold and Pusa Bahar during 1991-92 and 1992-93 (Tables 2 and 6). In another study conducted during 1991-92, two irrigations significantly increased the seed yield over one irrigation (Table 5). Rajput (1985) also found on the basis of results from Srignaganagar (Rajasthan) with mustard variety Varuna (T-59) on sandy loam soil, that depending on the growing season and rainfall, not more than two irrigations are needed for mustard, one at branching or flowering and second at siliqua development stage. Agarwal and Gupta (1991) and Tomer *et al.* (1992) also reported similar results. Significantly higher seed yield was reported when one irrigation was applied at pre-flowering stage (Yadav *et al.* 1995).

Effect of fertilizer and irrigation

Data in Table 6 revealed the highest seed yield (1.78 t/ha) under 3 irrigations with 60 kg N/ha. The crop without nitrogen under unirrigated condition produced only 0.22t/ha. seed yield. The response to a given level of irrigation is also determined by the fertility status or the does of fertilizer N applied. On low fertile soils where the crop has not been supplied any fertilizer, response to increasing level of irrigation is usually very low, but under adequate fertilization (60 kg N/ha) application of 3 irrigations (25,50 and 70 days after sowing) resulted in 4-fold increase in yield of both Pusa Bold and Pusa Bahar. An application of 60 kg N/ha and irrigating mustard (Pusa Bold) crop at sowing and flowering increased the seed yield to the extent of 260% as compared to unfertilized crop under same moisture regime (Table 4). It was interesting to note here that with 60 kg N/ha two irrigations gave 50% extra seed yield compared with one irrigation. Further the cumulative effect of two irrigations was more distinct when the crop was fertilized with 60 kg N/ha (Table 4).

Effect of fertilizer x irrigation on varieties

Data in Table 4 indicated an increase in the seed yield with the increased levels of N compared with the control. Nitrogen at 60 kg/ha resulted in significantly higher yield (2.05 t/ha) than 30 kg N/ha (1.38 t/ha). Indian mustard varieties responded to higher level of N compared with toria varieties. These varieties increased seed yield two-fold with 60 kg N/ha over 30 kg N/ha (Table 5). With 30 kg N/ha, seed yield of Pusa Bold increased by 46% over no nitrogen and by 52% with 60 kg N/ha when compared with 30 kg N/ha. Similar increase was noticed with variety Pusa Bahar (Table 6). Rajput (1985) reported an increase of 182% in yield with 80 kg N/ha over unfertilized crop at Bilaspur (M.P.).

All the toria and mustard varieties showed improvement in seed yield with application of 60 kg N/ha coupled with two irrigations over single irrigation with 30 kg N/ha. The seed yields were significant with the interaction of nitrogen x irrigation (Table 5).

The results of the present investigations indicated that among Toria varieties M-27, Toria Bhawani, PT.-303 and mustard varieties Pusa Bold, Pusa Bahar, Pusa Barani, RH-30 and Mustard Hybrid - 3 were promising when grown in rice fallows. The mustard crop could be sown by mid-November with 60 kg N/ha and preferably with two irrigations, first at sowing and the other at flowering to obtain seeds yields.

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by Pusa Basant. Varieties Pusa Bahar and Krishna also produced comparable seed yields. Pusa Bahar and Gujarat M-1 matured within shortest period (108 days). Among the toria group, Toria T-9 gave significantly higher yield compared with Toria Bhawani or standard check variety, M-27 (Table 1). On-farm varietal evaluation trials showed a good scope for growing hybrid mustard yielding 1.4 to 1.5 t/ha seed yield within 80 days duration.

Effect of sowing date

Under rainfed situation the second fortnight of October was found to be the optimum sowing period. any delay beyond 25 October resulted in significant reduction in seed yield (Table 2) as early own crop could utilize better the residual soil moisture. Under irrigated situation, sowing during the first fortnight of November gave higher seed yield than early sowing (25 October) or late sowing (30 November). Variety Pusa Bahar gave significantly higher yield than Pusa Bold when sown under residual moisture at each dates. The Crop performance was superior when sown on 15 November, which gave 22 and 24% increase in yield over 25 October and 30 November showings, respectively. This increase in seed yield was due to the low temperatures (20-22°C) prevailed during the 15 November sowing, which is one of the favourable weather component for a good crop of mustard. Irrigating the crop twice increased the seed yield substantially over the crop grown under residual moisture. Saini (1984) reported that at Ludhiana each fortnight delay in sowing beyond 1 October resulted in 11.7, 33.5, 51.3 and 66.0 decrease in yield compared with 1 October sowing. Delay in sowing beyond November 18 significantly reduced yield attributes and seed yield by 38 per cent (Samui *et al.* 1995).

Effect of N and K_2O

The crop responded to application of nitrogen upto 60 kg/ha, beyond which the yield did not increase significantly, whereas the crop responded to K_2O application upto 60 kg K_2O/ha. Though the NxK interaction was not significant, but when the crop was fertilized with 120 kg N and 60 kg K2O/ha the seed yield was increased to the extent of 17% over same level of K with 60 kg N/ha (Table 3). Application of 60 kg N and 30 kg K2O/ha produced higher quantity of mustard oil (34.1%) as compared to other fertilizer treatments. Similar trends of increased seed yield of mustard with increasing level of N have also been reported by Saini (1984) and Rajput (1985).

Effect of irrigation

Increasing number of irrigations progressively increased the yield of Pusa Bold and Pusa Bahar during 1991-92 and 1992-93 (Tables 2 and 6). In another study conducted during 1991-92, two irrigations significantly increased the seed yield over one irrigation (Table 5). Rajput (1985) also found on the basis of results from Srignaganagar (Rajasthan) with mustard variety Varuna (T-59) on sandy loam soil, that depending on the growing season and rainfall, not more than two irrigations are needed for mustard, one at branching or flowering and second at siliqua development stage. Agarwal and Gupta (1991) and Tomer *et al.* (1992) also reported similar results. Significantly higher seed yield was reported when one irrigation was applied at pre-flowering stage (Yadav *et al.* 1995).

Effect of fertilizer and irrigation

Data in Table 6 revealed the highest seed yield (1.78 t/ha) under 3 irrigations with 60 kg N/ha. The crop without nitrogen under unirrigated condition produced only 0.22t/ha. seed yield. The response to a given level of irrigation is also determined by the fertility status or the does of fertilizer N applied. On low fertile soils where the crop has not been supplied any fertilizer, response to increasing level of irrigation is usually very low, but under adequate fertilization (60 kg N/ha) application of 3 irrigations (25,50 and 70 days after sowing) resulted in 4-fold increase in yield of both Pusa Bold and Pusa Bahar. An application of 60 kg N/ha and irrigating mustard (Pusa Bold) crop at sowing and flowering increased the seed yield to the extent of 260% as compared to unfertilized crop under same moisture regime (Table 4). It was interesting to note here that with 60 kg N/ha two irrigations gave 50% extra seed yield compared with one irrigation. Further the cumulative effect of two irrigations was more distinct when the crop was fertilized with 60 kg N/ha (Table 4).

Effect of fertilizer x irrigation on varieties

Data in Table 4 indicated an increase in the seed yield with the increased levels of N compared with the control. Nitrogen at 60 kg/ha resulted in significantly higher yield (2.05 t/ha) than 30 kg N/ha (1.38 t/ha). Indian mustard varieties responded to higher level of N compared with toria varieties. These varieties increased seed yield two-fold with 60 kg N/ha over 30 kg N/ha (Table 5). With 30 kg N/ha, seed yield of Pusa Bold increased by 46% over no nitrogen and by 52% with 60 kg N/ha when compared with 30 kg N/ha. Similar increase was noticed with variety Pusa Bahar (Table 6). Rajput (1985) reported an increase of 182% in yield with 80 kg N/ha over unfertilized crop at Bilaspur (M.P.).

All the toria and mustard varieties showed improvement in seed yield with application of 60 kg N/ha coupled with two irrigations over single irrigation with 30 kg N/ha. The seed yields were significant with the interaction of nitrogen x irrigation (Table 5).

The results of the present investigations indicated that among Toria varieties M-27, Toria Bhawani, PT.-303 and mustard varieties Pusa Bold, Pusa Bahar, Pusa Barani, RH-30 and Mustard Hybrid - 3 were promising when grown in rice fallows. The mustard crop could be sown by mid-November with 60 kg N/ha and preferably with two irrigations, first at sowing and the other at flowering to obtain seeds yields.

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Table 1. Seed yield (t/ha) of Indian mustard (*Brassica juncea*) and toria (*B. campestris*) varieties during 1990-94.

Variety	1990-91	1991-92	1992-93	1993-94	Mean	Total duration (days)
Indian mustard						
Gujrat M-1	NT	1.16	1.23	1.18	1.19	108
Vardan	1.14	1.18	1.46	1.50	1.32	115
Varuna	1.05	1.51	1.57	1.46	1.39	115
Krishna	1.14	1.65	1.55	1.39	1.43	118
RLM 619	1.36	1.55	1.60	NT	1.50	115
Pusa Bold	1.56	1.66	1.78	1.63	1.66	115
Pusa Bahar	1.57	1.58	1.60	1.53	1.57	108
Pusa Barani	NT	NT	NT	1.49	1.49	110
Pusa Basant	NT	NT	NT	1.62	1.62	110
C.D.(P=0.05)	0.13	0.15	0.15	0.15		
Toria group						
M-27	0.66	0.77	0.70	0.64	0.69	80
Toria Bhawani	0.93	0.52	0.50	0.79	0.68	90
Toria T-9	0.98	0.88	0.50	0.66	0.75	90
TL-15	0.29	0.31	0.70	NT	0.43	85
TLC-1	0.31	0.44	NT	0.51	0.42	90
RL 1359	0.63	0.71	NT	NT	0.67	90
Mean	0.63	0.60	0.60	0.65		
C.D.(P=0.05)	0.07	0.07	0.05	0.07		

NT - Not tested

Table 2. Effect of date of sowing and irrigation on seed yield (t/ha) of two Indian mustard varieties in pre-winter season, 1991-92.

Irrigation	Date of sowing					
	25 October		15 November		30 November	
	Pusa Bold	Pusa Bahar	Pusa Bold	Pusa Bahar	Pusa Bold	Pusa Bahar
No irrigation (residual moisture)	0.35	0.44	0.22	0.35	0.16	0.23
Two irrigations	0.73	1.18	1.11	1.21	0.25	0.33
Mean	0.54	0.81	0.87	0.78	0.21	0.28
C.D. (*P*=0.05)						
Irrigation		0.11				
Date of Sowing		0.06				
Varieties		0.06				
Varieties x Irrigation		0.08				

Table 3. Effect of nitrogen and potassium levels on the seed yield (t/ha) of mustard variety RH-30, rabi 1993-94.

Level of K_2O (kg/ha)	Level of N(kg/ha)					
	0	30	60	90	120	Mean
0	0.85	0.99	1.23	1.38	1.28	1.15
30	1.14	1.17	1.43	1.53	1.55	1.37
60	1.35	1.48	1.54	1.53	1.80	1.54
Mean	1.12	1.21	1.40	1.48	1.55	
C.D. (*p*=0.05)	N levels	: 0.22				
	K_2O levels	: 0.09				

Table 4. Seed yield (t/ha) of mustard as influenced by moisture regimes and levels of nitrogen, rabi *1988-89*

Moisture regimes	N level, kg/ha			
	0	30	60	Mean
Irrigation after sowing (I1)	0.24	1.17	1.60	1.00
I1+Irrigation at branching	0.49	1.41	2.09	1.33
I1+Irrigation at flowering	0.65	1.60	2.34	1.53
I1+Irrigation at siliqua initiation	0.50	1.14	2.40	1.35
I1+Irrigation at siliqua development	0.67	1.60	1.79	1.35
Mean	0.51	1.38	2.04	
C.D. (P=0.05) Moisture regimes (1) :	0.03			
N levels :	0.03			

Table - 5 : Mustard seed yield (t/ha) as influenced by irrigation and N level, rabi 1991-92

Variety	One irrigation			Two irrigations		
	N level (kg/ha)					
	30	60	Mean	30	60	Mean
Toria T-9	0.76	0.82	0.79	1.01	1.50	1.25
TLC-1	0.89	0.97	0.93	0.93	1.87	1.40
Toria Bhawani	0.72	0.81	0.76	1.03	1.98	1.50
M-27	0.86	0.94	0.90	1.16	1.92	1.54
RLM 619	0.52	0.72	0.62	1.30	1.70	1.50
Varuna	0.86	1.56	1.21	1.26	2.14	1.70
Kranti	0.74	1.44	1.09	1.10	2.24	1.66
Krishna	0.66	1.22	0.94	0.94	1.94	1.44
Pusa Bold	0.72	1.02	0.87	1.25	2.20	1.72
Pusa Bahar	0.70	1.12	0.91	1.23	2.15	1.69
Mean	0.74	1.06	0.90	1.12	1.96	1.59
C.D. (P=0.05)	varieties (V) :	0.44				
	N levels (N) :	0.39				
	Irrigation (I) :	0.51				
	V x N :	0.31				
	V x I :	0.47				
	N x I :	0.55				
	V x N x I :	0.61				

Table 6. Effect of irrigation and nitrogen on seed yield (t/ha) of Indian mustard (Winter season, 1992-93)

Irrigation	Nitrogen (kg/ha)						
	0		30		60		Mean
	Pusa Bold	Pusa Bahar	Pusa Bold	Pusa Bahar	Pusa Bold	Pusa Bahar	
Residual moisture (no irrigation)	0.22	0.26	0.32	0.38	0.41	0.37	0.33
1 irrigation at 35 DAS	0.32	0.35	0.46	0.46	0.56	0.78	0.48
2 irrigations at 25, 50 DAS	0.58	0.51	0.72	1.15	0.88	1.43	0.88
3. irragation at 25, 50 & 70 DAS	0.55	0.42	0.91	0.88	1.78	1.65	1.03
Mean (N)		0.40		0.66		0.98	
Mean (Variety)	*0.41*	*0.38*	*0.60*	*0.72*	*0.91*	*1.06*	
C.D. (P=0.05)	Irrigation	: 0.15					
	Nitrogen	: 0.21					
	Varieties	: 0.8					

DAS - Days after sowing

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CORRELATION AND REGRESSION STUDIES BETWEEN DIFFERENT YIELD ATTRIBUTES AND SEED YIELD IN MUSTARD (*Brassica juncea* L.)

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ABSTRACT

Character associations involving dry matter/plant at 90 days after sowing (DAS), at harvest, dry matter of leaves at 60 DAS, total branches/plant, number of Siliqua/plant, seed weight/plant, 1000-seed weight, oil content (%), total N uptake and total 'S' uptake, were determined amongst themselves with seed yield, when fertilized with different levels of nitrogen and sulphur taking variety Kranti. Seed yield was positively and significantly associated with all the characters studied except with oil content which was found negatively correlated during both the years.

Key Words : *Brassica juncea:* correlation: regression

INTRODUCTION

Significant achievements have been made in recent times in the development of high yielding and fertilizer responsive varieties. The increased yield of the varieties, in general is mainly attributed to improved plant type and high harvest index (Jani and Kulshrestha, 1976). Differential trends in seed yield of mustard under a particular agro-climatic condition have been noticed due to varying nutrient levels, particularly nitrogen and sulphur fertilization. Application of fertilizers containing these two nutrient elements has been recognised as the most important constraint and often inadequate application of N and S in farmer's fields reduce the yield level of mustard. In sulphur deficient soils, the full yield potential of mustard can not be realised regardless of application of other nutrients or adoption of improved crop management practices.

Seed yield is a complex metric trait which is the end result of a number of traits often interrelated with each other. Understanding of various yield attributes that influences the final yield of the crop, assumes greater importance. However, the knowledge of such association would only be a complimentary effort. Keeping this in view, the present investigation was carried out to find out the correlation between yield attributes with seed yield under varying levels of nitrogen and sulphur fertilization.

MATERIALS AND METHODS

A field experiment was laid out at the crop Research Centre of G.B.Pant University of Agriculture and Technology, Pantnagar during Rabi 1992-93 and 1993-94 in a randomised block design with three replications comprising five nitrogen levels (0.40.80.120 and 160 Kg N/ha) and four sulphur levels (0.20.40 and 60kg S/ha). The sowing was done on 30 October, 1992 and 24 October, 1993 taking variety, Kranti. The crop was sown at 30 cm row, spacing and plant to plant spacing of 15cm was maintained by thinning at 15 days after sowing. The soil was silty clay loam with pH 7.1 and 7.5 low in total nitrogen (0.085

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and 0.089%) and sulphur (7.1 and 7.5ppm) and medium in phosphorus (60 and 50kg P/ha) and Potassium (292 and 291kg K/ha) during 1992-93 and 1993-94, respectively. Uniform basal application of 40kg P_2O_5, 20kg K_2O, full sulphur and 50% N dose as per the treatment was made. Rest of the nitrogen was top dressed after first irrigation. The other cultural practices were performed as per recommendation. The dry matter of various plant parts was recorded at 30,60,90 and 120 days after sowing and yield attributes were recorded at harvest and was reported as the average of five plants. The pod yield (kg/ha) reported was the converted pod yield/plant. Correlation coefficients between various characters were worked out as procedure of Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

The study showed that there was a positive and significant correlation between all the growth and yield contributing characters with the seed yield except with the oil content which was negatively correlated during both the years (Table 1 and Fig2).

Highest positive correlation was recorded between total nitrogen uptake and sulphur uptake (0.999*) and (0.998*) during both the years, respectively (Fig 2). Seed yield also had positive correlation with dry matter at 90 DAS (0.949* and 0.919*), dry matter at harvest (0.946* and 0.893*), drymatter of leaves at 60 DAS (Fig 1) (0.934* and 0.889*), total branches/plant (0.924* and 0.836*), number of Siliqua/plant (0.930* and 0.875*), seed weight/plant (Fig 2) (0.974* and 0.948*) and 1000-seed weight (0.948* and 0.889*) during 1992-93 and 1993-94, respectively.

The correlation between seed yield and oil content was negative during both the years (0.315 and 0.409). Sinha (1979) also reported similar findings.

Regression studies revealed that there was significant and positive regression of seed yield with dry matter accumulation/plant at 90 DAS and at harvest, dry matter accumulation/plant at 60 DAS (Fig 1), branches/plant, no. of siliquae/plant and total seed weight/plant (Fig 2). The study, thus provides an understanding of the association of seed yield with some growth and yield attributes.

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Table 1 . Correlation coefficients between different characters during 1992-93 and 1993-94.

Characters	Dry matter/ plant at harvest (g)	Dry matter of leaves/ plant at 60 DAS	Total branches/ plant	No. of silliquae/ plant	Total seed weight/ plant (g)	1000 seed weight (g)	Oil content (%)	Total N uptake (kg/ha)	Total S uptake (kg/ha)	Yield (q/ha)
Dry matter/ plant (g)	0.996* (0.991*)	0.990* (0.991*)	0.980* (0.975*)	0.983* (0.985*)	0.986* (0.974*)	0.979* (0.983*)	-0.204* (0.333)	0.982* (0.973)*	0.985* (0.978)*	0.949* (0.919)*
Dry matter/plant at harvest (g)		0.991* (0.993*)	0.979 (0.972*)	0.983* (0.993*)	0.982* (0.978*)	0.974* (0.986*)	-0.229* (-0.413*)	0.984* (0.991*)	0.987* (0.995*)	0.946* (0.893*)
Dry matter of leaves/plant at 60 DAS (g)			0.991* (0.974*)	0.995* (0.995*)	0.982* (0.970*)	0.980* (0.982*)	-0.243 (-0.393)	0.990* (0.987*)	0.995* (0.992*)	0.934* (0.889*)
Total branches/ plant				0.988* (0.982*)	0.972* (0.933*)	0.985* (0.986*)	-0.163 (-0.222)	0.970* (0.946*)	0.978* (0.959*)	0.924* (0.836*)
No. of siliquea/ plant					0.985* (0.972*)	0.969* (0.989*)	-0.263 (-0.361*)	0.991* (0.986*)	0.994* (0.992*)	0.930* (0..875*)
Seed weight/ plant (g)						0.970* (0.968*)	-0.313 (-0.446)	0.990* (0.981*)	0.989* (0.977*)	0.974* (0.948*)
1000-seed (g) Weight							-0.160 (-0.320*)	0.959* (0.971*)	0.965* (0.978*)	0.948* (0.889*)
Oil content (%)								0.361 (-0.508*)	-0.326 (-0.470*)	-0.315 (-0.409*)
Total N uptake (kg/ha)									0.999* (0.998*)	0.946* (0.894*)
Total S uptake (kg/ha)										0.942* (0.984*)

* Significant at 5% level of probability, Figures in the parenthesis indicate the data during 1993-1994.

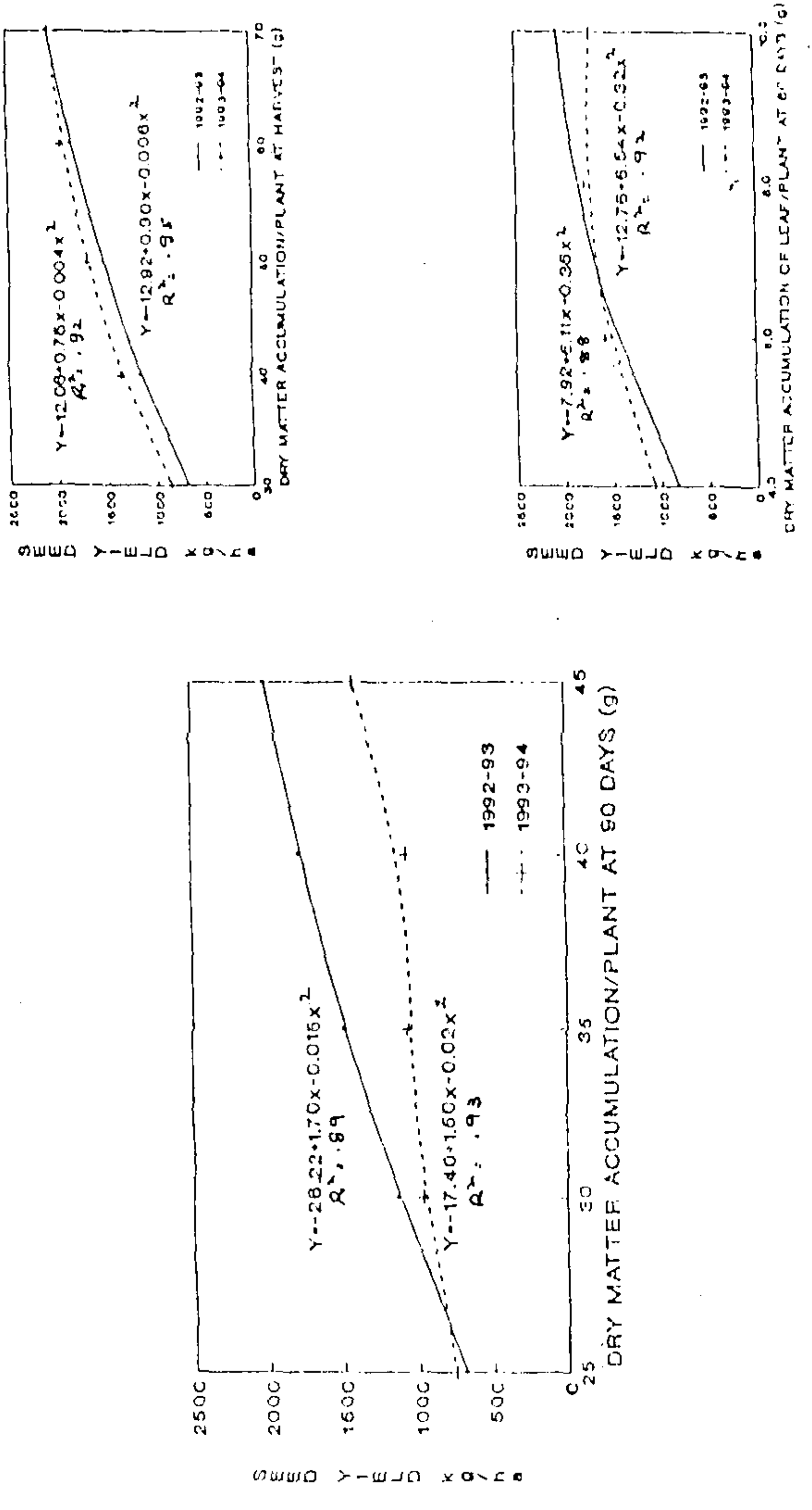

Fig - 1 : Relationship of dry matter accumulation with seed yield

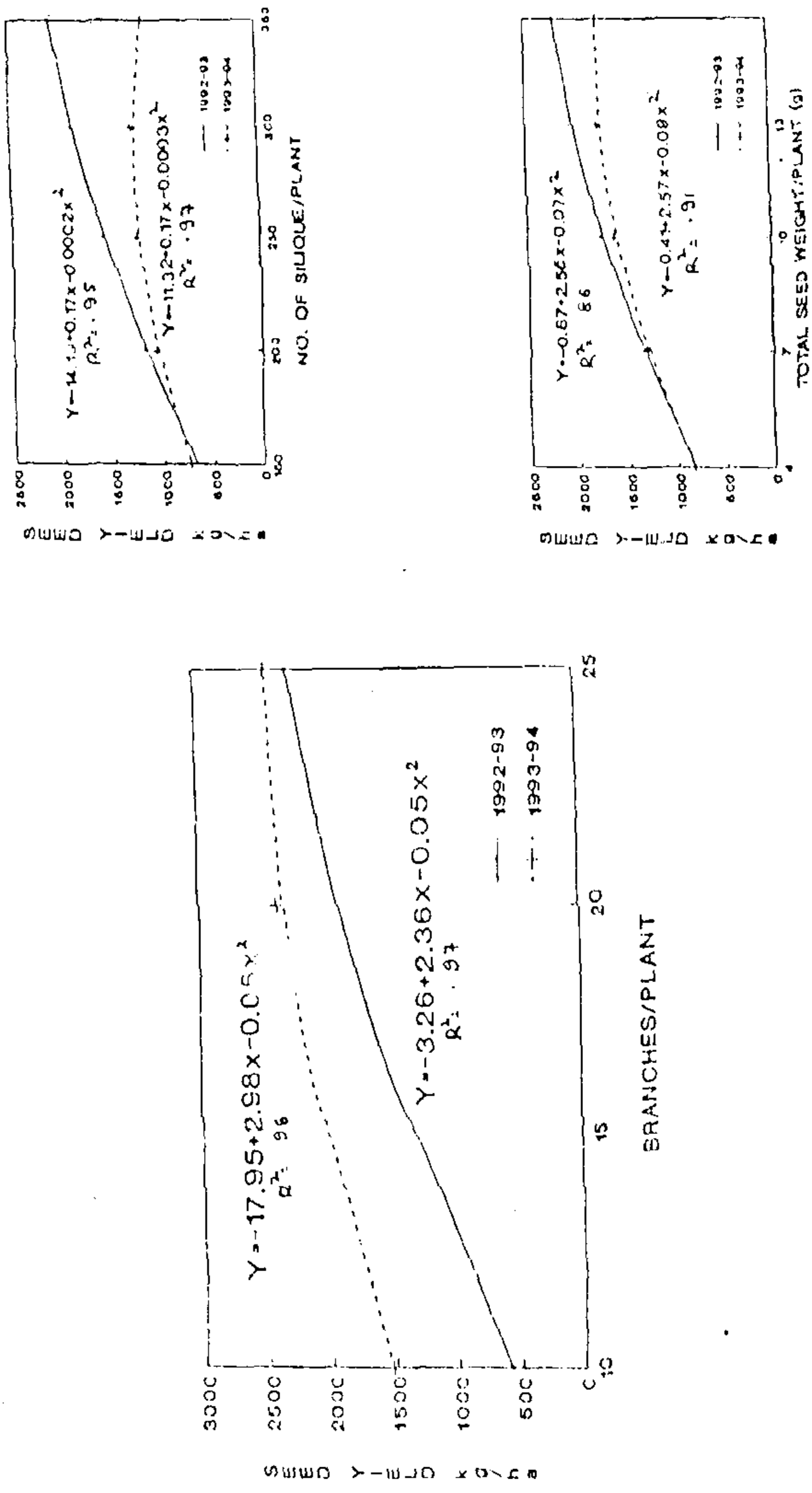

Fig - 2 : Relationship of yield at tributes with seed yield.

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EFFECT OF DATES OF SOWING ON PERFORMANCE OF MUSTARD (*Brassica juncea* (L) *Czernji* and *Cosson*) VARIETIES IN NON-TRADITIONAL AREA OF ANDHRA PRADESH

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ABSTRACT

An experiment with three dates of sowing and eight mustard cultivars was conducted in Northern Telangana region of Andhra Pradesh (a non traditional area for mustard) during winter seasons of 1994-95 and 1995-96. With the delay in sowing of mustard from Oct 4 (646 kg/ha) to Oct 19 and Nov. 5, there was 6.2 and 24.8 percent decrease in seed yield. Among cultivars tested- TM 9. Varuna and TM 21 gave significantly higher seed yield than Divya and Kranthi and were on par with Vardhan, GM 1 and TM 18. The interaction between dates of sowing and cultivars was significant where in higher seed yield was obtained with vardhan, TM 18 and GM 1 in 4 October and TM 21 in October 19 sowing.

Key words: Dates of sowing, mustard, varieties

INTRODUCTION

In Northern Telangana mustard is grown to a smaller extent though the temperatures are suitable. It is mostly raised as a mixed crop with chillies, garlics and onion at very low population. The experiments conducted previously on mustard at the research station indicated that an yield of 1.6 t/ha could be obtained (RARS. 1992-93). There are reports of optimum time of sowing for irrigated and rainfed conditions for North Indian conditions (Sharma *et al*, 1992). The mustard crop planted on september 30 produced significantly higher seed yield than that planted there after (Singh and Singh, 1991). The information on different dates of sowing involving a number of cultivars for non - traditional area like Northern Telangana of Andhra Pradesh is not available. Hence, this investigation was conducted for two winter seasons to identify optimum sowing time for different varieties of mustard in the region.

MATERIALS AND METHODS

Field experiments conducted during winter seasons of 1994-95 and 1995-96 at Regional Agricultural Research Station, Jagtial on sandy clay loam soil (red chalka) having a pH of 7.3, 272 kg/ha available nitrogen, 8.9 kg/ha available P_2O_5 and 308 kg/ha available K_2O. Three dates of sowing (Oct 4, 19 and Nov 5) and eight cultivars of mustard were tested (Table 1) in split-plot design with dates of sowing in main-plots and cultivars in sub-plots. The treatments were replicated three times. A fertilizer dose of 60 kg N, 40 kg P_2O_5 and 40 kg K_2O /ha was given to all the treatments uniformly. The crop was sown at a spacing of 30 cm x 10 cm. Entire level of P_2O_5 and K_2O was applied at sowing. Nitrogen was applied in three equal splits-at sowing and at 21 and at 21 and 41 days after sowing (DAS). Weeding was done at 20 and 40 DAS in each date of sowing. Three irrigations were given at rosette, flowering and pod filling stages besides one at sowing. Monocrotophos/endosulphon @ 1.5 ml/ 1 of water was sprayed at 50 DAS. The crops were harvested at their maturity.

The maximum temperature at sowing was 33.1°C, 31.8°C and 31.1°C and minimum temperature was 21.3°C, 20.5° and 17.0°C respectively in Oct 4, Oct 19 and Nov 5 dates of

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sowing. During crop growth period maximum temperature ranged between 27.7 and 34.1°C 27.5 and 21.7°C. 9.4 and 20.6°C and 9.4 and 23.1°C in Oct 4, Oct 19 and Nov 5 dates of sowing, respectively.

RESULTS AND DISCUSSION

Dates of sowing :

There was significant reduction in plant height with delay in sowing from Oct 4 to Oct 19 and Nov 5. The total dry matter yield decreased with delay in sowing from Oct 4 to Oct 19 and Nov 5. In addition, delay in sowing by 15 days after Oct 4, significantly lowered the number of branches per plant, however, further delay in sowing to Nov 5 did not affect the number of branches per plant. On the other hand, the number of siliquae per plant decreased with delay in sowing from Oct 4 to Oct 19 and Nov 5.

Sowing on Oct 4 resulted in significantly higher seed yield (646 kg/ha) over that of Ogt 19 (646 kg/ha) sowing. The seed yield reduction was 6 and 25% when the crop was sown on Oct 19 and Nov 5 as compared to Oct 4. It is well known that shorter days and lower temperatures under delayed sowing in the initial stage of crop growth reduce photosynthesis and other physiological activities of the plant (Babu. 1985). This was probably the reason for reduced growth and branching resulting in lesser number of siliquae per plant in Oct 19 and Nov 5 sown crops than Oct 4 sown crop. More over, rise in temperature during later period of growth of late sown crop further decreased the photosynthate accumulation in plants due to decreased growth period of the crop (Jai kumar, 1993).

Varieties:

Among cultivars tested. GM 1 was taller, while Divya was shorter in height (Table 1). Cultivar Divya recorded lowest seed yield inspite of having more branches and more siliquae per plant than all other cultivars. Among the cultivars tested, TM 9. Varuna and TM 21 recorded significantly higher seed yield over Divya and Kranthi and were on per with Vardhan. GM 1 and TM 18 (Table 2). The latter three cultivars and also Kranti offered significantly higher seed yield than Divya.

The interaction between dates of sowing and cultivars was significant. The seed yield decreased significantly in Vardhan, GM 1. TM 9. TM 18 with delay in sowing from Oct 4 to Oct 19 and the difference in yield in these two dates of sowing was not significant in Varuna. The seed yield was significantly higher in Oct 19 sowing over Oct 4 and NOv 5 sowing in Divya and TM 21 yield decreased significantly in Nov 5 sowing compared to Oct 4 sowing in these varieties.

Sowing during November was not congenial for mustard in Northern Telangana because of drastic reduction in seed yield. Higher seed yield of mustard could be realized by sowing cultivars - Vardhan. GM 1 or TM 18 during first week of Oct (Oct 4) or by sowing cultivar TM 21 during third week of Oct (Oct 19).

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Table 1. Effect of dates of sowing on growth, seed yield and yield attributes of mustard (mean of 1994-95)

Treatments	Plant height (cm)	No. of branches/ plant	No. of siliquae/ plant	Seed yield (kg/ha)	Stalk yield (kg/ha)
Dates of sowing					
Oct 4	138	4.6	142	646	2111
Oct 19	131	3.5	112	606	1912
Nov 5	129	3.5	93	486	1398
S.Em±	2	0.1	4	9	39
LSD (0.05)	6	0.3	12	31	126
Cultivars					
Varuna	138	3.1	80	605	2096
Vardhan	137	3.6	91	599	1926
GM 1	145	3.4	97	599	1806
Kranthi	137	4.0	130	567	2079
Divya	122	4.7	132	437	1389
TM 9	130	4.4	126	619	1839
TM 18	128	4.1	132	601	1754
TM 21	125	3.9	130	607	1567
S.Em±	3	0.1	5	11	42
LSD (0.05)	7	0.4	13	30	117

Table 2. Effect of dates of sowing on seed yield (kg/ha) of mustard cultivars (Mean of 1994-95 and 1995-96)

	Cultivars								
	Varuna	Vardhan	GM1	Kranthi	Divya	TM 9	TM 18	TM 21	Mean
Dates of sowing									
Oct 4	619	714	717	677	412	666	729	635	646
Oct 19	669	602	591	527	557	613	550	737	606
Nov 5	526	480	490	496	341	579	524	449	486
Mean	605	599	599	567	437	619	601	607	

	S.Em±	LSD (0.05)
Dates of Sowing	9	31
Varieties	11	30
Dates x Varieties	19	52

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INFLUENCE OF VAM INOCULATION AND PHOSPHORUS ON DRY MATTER PRODUCTION AND SEED YIELD OF TWO SUNFLOWER (*Helianthus annuus* L.) GENOTYPES*

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ABSTRACT

The field response of two sunflower genotypes (Morden and MSFH-8) to inoculation with vesicular arbuscular mycorrhizal fungus, *Glomus fasciculatum* at three P levels (38, 56 and 75 kg P_2O_5 ha^{-1} equal to 50,75 and 100 per cent of the recommended dose of phosphorus, respectively) on Vertisol in terms of dry matter production and translocation to different plant parts, oil and seed yields was studied during summer 1993. The results showed that MSFH-8 performed better than Morden. Application of P fertilizer increased the uptake of phosphorus, dry matter production at all the growth stages, except at 30 days after sowing (DAS) and seed yield upto 75 kg P_2O_5 ha^{-1} but these characteristics were on par with those observed at 56 kg P_2O_5 ha^{-1} Inoculation with *Glomus fasciculatum* increased seed yield, oil yield, total dry matter (16%)and stalk yield over uninoculated plants. The total dry matter production in leaves and stem (at 60 DAS) and in stem and head (at harvest) of mycorrhizal plants at 38 kg P_2O_5 ha^{-1} were more than the non mycorrhizal plants receiving 75 kg P_2O_5 ha^{-1} The positive effect of mycorrhizal inoculation showed decreasing trend at P levels higher than 38 kg P_2O_5 ha^{-1}.

Key words: Phosphorus, VA mycorrhizae, sunflower, yield, puptake

INTRODUCTION

Sunflower, one of the major oilseed crops of India, has a high phosphorus requirement. The variation of seed yield in plants can be attributed to the dry matter production pattern. The total dry matter production alone, however does not reflect the efficiency of a plant. The rate of dry matter accumulation in the ear and partitioning of dry matter between shoot and ear would indicate the efficiency of a plant(Watson, 1952). Increase in crop productivity can be achieved by improving the partitioning of assimilates, but such developments require a better understanding of the integration of source-sink relationship. Beneficial effects of VAM on plant growth has largely been attributed to higher P uptake and consequently better P nutrition of mycorrhizal inoculated plants. Pot culture trials have proved that sunflower responds to inoculation with VAM fungi (Thomson, 1987; Jones and Sreenivasa, 1993). While very few field experiments have been carried out on crops viz., wheat (Hayman, 1970) and barley (Hayman et al., 1975), no such studies were carried out on sunflower under field conditions. Hence, the present investigation was aimed at studying the effect of *Glomus fasciculatum* on P availability at different P levels, dry matter production and its apportioning into different parts of sunflower genotypes grown on a Vertisol.

MATERIALS AND METHODS

A field experiment was conducted at Main Research Station, University of Agricultural Sciences, Dharwad on Vertisol with pH 7.6; E.C 0.35 dS m-1; organic carbon 0.63%; available N 126 kg ha^{-1}; P_2O_5 32 kg ha^{-1}; and K_2O 295 kg ha^{-1} under irrigated conditions during summer, 1993. The experiment had twelve treatments comprising

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of two sunflower genotypes (Morden and MSFH-8), three P levels (38, 56 and 75 kg P_2O_5 ha^{-1} equal to 50, 75 and 100 per cent of the recommended dose of phosphorus, respectively) applied as single superphosphate with and without inoculation of VA-mycorrhizal fungus, *Glomus fasciculatum*. The experiment was laid out in a randomised block design with four replications, on plots of 5.0 m x 3.6 m in size. Nitrogen @ 62.5 kg ha^{-1} and potassium @ 62.5 kg ha^{-1} were applied in the form of urea and muriate of potash, respectively. *Glomus fasciculatum* (Thaxt) Gerd and Trappe, multiplied in sterilized sand soil mix (1:1 volume) using Rhodes grass (*Chloris gayana* Kunth.) (Sreenivasa and Bagyaraj, 1988) was placed 2 cm below the sunflower seeds @ 30 g per dibbled spot. The inoculum consisted of colonized root fragments, hyphae and Chlamydospores (126 per 50 g inoculum). In each treatment, 5 plants were uprooted by wetting the root zone with an additional amount of water at 30 days after sowing (DAS), 60 DAS and at harvest. The shoots were severed at ground level, partitioned and dried at 70°C to constant weight to record dry weights of root, leaf, stem and head. Phosphorus was analysed by vanadomolybdate phosphoric yellow colour method (Jackson, 1967). Percent root colonization (Phillips and Hayman, 1970) and Chlamydospore count (Gerdemann and Nicolson, 1963) were determined. The seed yield was computed by using net plot (7.2m^2) yield. Analysis of variance was done by MSTAT, statistical programme and least significant difference was used for mean separation.

RESULTS AND DISCUSSION

Performance of genotypes

Cultivar MSFH-8 responded well to the inoculation of *Glomus fasciculatum*. Per cent root colonization (PRC) and Chlamydospore count at 30 and 60 DAS were significantly higher in MSFH-8 than in Morden (Table 2). The uptake of P (12%), total dry matter (TDM) production (30%), oil (38%), stalk (17%) and seed (62%) yields were significantly higher in MSFH-8 than in Morden (Table 1). According to Watson (1952), the rate of dry matter accumulation in ear and partitioning of dry matter between shoot and ear indicates the efficiency of a genotype. In the present study, the contribution of leaves and stem to TDM at 60 DAS was higher (35 and 43%, respectively) in MSFH-8 as compared to Morden (34 and 38%, respectively) and contribution of stem to TDM declined from 43 to 37% at harvest in MSFH-8. While, it remained constant (38% at 60 DAS and 37% at harvest) in Morden. This indicates that more of photosynthates produced after flowering are diverted from stem to head in MSFH-8 than in Morden. Deshpande, (1990) observed higher translocation efficiency in Suncross-20 than in Morden.

Effect of phosphorus

The seed and oil yields increased with increase in level of P application (Table 2). The seed, oil yields and TDM recorded with 75kg P_2O_5 ha^{-1} were significantly higher than with 38 kg P_2O_5 ha^{-1}. However, no significant differences were observed between 56 and 75 kg P_2O_5 ha^{-1}. TDM showed a strong correlation with seed yield ($r=0.975^{**}$). At all the growth stages, dry matter accumulation in roots, leaves, stem and head were increased upto the level of 75kg P_2O_5 ha^{-1} (Table 1). Phosphorus which is a constituent of phosphonucleotides, is known to help for increased cell division and expansion of cells (Black, 1965). In general, P uptake at different growth stages increased with increase in the level of P (Table 2). This might have led to higher dry matter production and its accumulation in reproductive parts at higher levels of P, which resulted in higher seed yield.

Effect of VA mycorrhizae

Sunflower plants inoculated with *Glomus fasciculatum* recorded higher per cent root colonization and Chlamydospore count than uninoculated plants (Table 2). Inoculation of *Glomus fasciculatum* influenced the P uptake, dry matter accumulation in root, stem and head (at all the growth stages) in leaf (at DAS), TDM(at 60 DAS and at harvest), seed, oil and stalk yields more than in uninoculated plants. Seed yield is the reflection of dry matter accumulation in reproductive parts. Mycorrhizal plants had higher dry matter in leaves (Table 1) which enhanced the photosynthetic capacity of the plant by increasing leaf area and ultimately lead to higher head dry matter (47 g) than in uninoculated plants (41g). Apart from this, the dry matter accumulation in roots was higher in mycorrhizal plants, perhaps due to better uptake of nutrients from soil. Vesicular arbuscular mycorrhizae cause greater uptake of P by their expanded network of hypae (Gianinazzi and Gianinazzi, 1983). Positive correlations were observed in case of percent root colonization (0.58*) and spore count (0.69) with total P uptake. Such correlations between increased growth and yield of crop and the extent of mycorrhizal colonization were observed by Daft and Nicolson (1966).

Interactions between phosphorus and VA mycorrhizae

In uninoculated plants, the leaf (60 DAS), stem (60 DAS and at harvest) and total (60 DAS and at harvest) dry matter increased significantly with increase in P levels (Table 1). But in inoculated plants, there was no increase in TDM at higher P levels. It shows that the efficiency of VAM fungi is at lower levels than at higher levels of P application. At all P levels, mycorrhizal plants recorded higher dry matter accumulation in leaves (at 60 DAS), stem (at both the stages) and head (at harvest) than in uninoculated plants (Table 1). The principal way in which VAM fungi improves plant growth is through increased P uptake. Correlation studies showed positive relation between P uptake and seed yield (0.704*). In addition to uptake of P, it will also help in the uptake of Zn, Cu, Fe, Mn etc., (Sreenivasa et al.,1993) and further they are known to produce growth promoting substances (Allen, 1991) which perhaps result in higher dry matter production and seed yield.

This study has clearly bought out that MSFH-8 performed better than Morden. Among three P-levels, application of 56 kg P_2O_5 ha^{-1} is better than application of either 38 or 75 kg P_2O_5 ha^{-1}. Inoculation with VAM fungus, at 38 kg P_2O_5 ha^{-1} resulted in efficient utilization of P which inturn increased dry matter production and their accumulation in different parts, which ultimately lead to higher seed yield.

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Table 1. **Root, leaf, stem, head and total dry matter at different growth stages of sunflower genotypes inoculated with *Glomus fasciculatum* at different P levels.**

Treatment	Dry matter (g plant^{-1})														
	Root			Leaf			Stem			Head		Total		
	30 DAS	60DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	60 DAS	Harvest	30 DAS	60DAS	Harvest
Genotypes															
Morden*	1.07	9.38	8.63	5.88	21.89	7.52	2.25	23.39	32.62	12.15	37.37	9.20	66.81	86.14
MSFH-8*	1.08	11.69	8.43	5.42	30.83	10.02	2.48	38.42	43.33	5.46	44.14	8.98	86.40	105.92
S.Em. ±	0.03	0.29	0.20	0.21	0.63	0.41	0.10	0.74	0.51	0.22	0.60	0.22	0.94	0.90
L.S.D.(P=0.05)	NS	0.84	NS	NS	1.81	1.20	NS	2.14	1.47	0.65	1.73	NS	2.71	2.71
P.Levels															
(Kg $P_2O_5 ha^{-1}$)															
38	0.99	9.84	7.67	5.66	25.72	8.28	1.98	29.34	35.64	8.49	41.30	8.63	73.39	92.89
56	1.02	10.47	8.63	5.68	26.51	9.38	2.60	30.50	38.46	9.18	44.22	9.30	76.66	100.69
75	1.20	11.29	9.28	5.36	26.84	8.66	2.52	32.88	39.83	8.73	46.89	9.08	79.74	104.66
S.Em. ±	0.04	0.44	0.24	0.26	0.77	0.51	0.12	0.91	0.63	0.23	0.73	0.27	1.15	1.11
L.S.D.(P=0.05)	0.11	1.02	0.69	NS	NS	NS	0.37	2.63	1.80	NS	2.12	NS	3.32	3.33
VAM															
Inoculated	1.13	11.15	9.16	5.74	29.59	9.32	2.81	33.58	41.23	9.57	47.06	9.68	83.89	106.77
Uninoculated	1.02	9.92	7.89	5.34	23.13	8.23	2.22	28.23	34.72	8.04	41.21	8.58	69.32	94.69
S.Em. ±	0.03	0.29	0.20	0.21	0.63	0.41	0.10	0.74	0.51	0.22	0.60	0.22	0.94	0.90
L.S.D. (P=0.05)	0.09	0.84	0.57	NS	1.81	NS	0.30	2.14	1.47	0.65	1.73	0.66	2.71	2.71
P X VAM															
VAM Inoculated															
38	1.50	11.05	8.39	5.22	30.20	9.13	2.11	33.49	39.68	8.69	45.69	8.83	83.43	102.89
56	1.09	11.08	9.35	5.89	30.37	9.99	2.81	34.00	41.93	9.57	47.06	9.79	85.07	104.86
75	1.24	11.31	9.74	6.10	28.20	8.83	2.81	33.25	42.08	8.70	48.43	10.15	81.46	109.08
VAM Uninoculated															
38	0.93	8.63	6.95	5.50	21.20	7.43	1.84	25.18	31.60	8.29	36.91	8.27	63.30	82.89
56	0.96	9.86	7.91	5.47	22.65	8.76	2.39	26.99	34.98	8.79	41.37	8.83	68.29	93.02
75	1.16	11.27	8.82	5.22	25.49	8.49	2.22	32.51	37.58	8.76	45.36	8.60	78.03	100.25
S.Em.±	0.06	0.57	0.34	0.21	1.09	0.71	0.18	1.29	0.88	0.35	1.03	0.37	1.63	1.56
L.S.D.(P=0.05)	NS	NS	NS	NS	3.13	NS	NS	3.71	2.55	NS	3.00	NS	4.69	4.70

NS - Non Significant, DAS - Days After Sowing : * Morden was harvested at 90 DAS and MSFH-8 at 105 DAS.

Table 2 . Per cent root colonization, spore count, P uptake at different growth stages, stalk, seed and oil yields of sunflower genotypes inoculated with *Glomus fasciculatum* at different P levels.

Treatments	Per cent root colonization			Spore count per 50 g soil			Total P uptake (kg ha^{-1})			Stalk yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Oil yield (kg ha^{-1})
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest			
Genotypes												
Morden*	46.70	61.50	62.04	103.00	194.00	118.00	1.28	11.95	16.64	5433.00	1327.00	505.00
MSFH-8*	49.60	64.08	64.79	114.00	206.00	118.00	0.96	12.40	18.51	6582.00	2156.00	818.00
S.Em±	0.30	0.44	0.43	0.90	1.80	9.20	0.06	0.30	0.35	136.00	12.00	7.00
L.S.D(P=0.05)	0.90	1.27	1.25	2.50	5.10	NS	0.16	NS	1.02	409.00	35.00	23.00
P - levels (kg P_2O_5 ha^{-1})												
38	51.10	67.60	68.90	115.00	229.00	122.00	0.95	10.89	15.70	5690.00	1654.00	628.00
56	48 20	63.20	63.60	104.00	197.00	120.00	1.20	·12.18	17.69	6058.00	1764.00	666.00
75	45.30	57.60	57.70	103.00	174.00	112.00	1.21	13.45	19.34	6276.00	1810.00	688.00
S.Em ±	0.40	0.54	0.53	1.10	2.10	11.30	0.07	0.36	0.43	123.00	16.00	9.00
L.S.D(P=0.05)	1.10	1.60	1.53	3.10	6.20	NS	0.20	1.07	1.25	NS	48.00	28.00
VAM												
Inoculated	88.10	81.80	84.20	163.00	272.00	170.00	1.27	14.22	19.91	6461.00	1853.00	710.00
Uninoculated	47.00	43.70	42.62	55.00	127.00	65.00	0.96	10.12	15.25	5553.00	1628.00	612.00
S.Em ±	0.30	0.44	0.43	0.90	1.80	9.20	0.06	0.30	0.35	136.00	12.00	7.00
L.S.D(P=0.05)	0.90	1.27	1.25	2.50	5.10	26.60	0.16	0.87	1.02	409.00	35.00	23.00

*NS= Non significant. DAS - Days after sowing : * Morden was harvested at 90 DAS and MSFH-8 at 105 DAS.*

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YIELD AND YIELD COMPONENTS OF SUNFLOWER (*Helianthus annuus* L.) CULTIVARS AS INFLUENCED BY SEASON*

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ABSTRACT

A field experiment was conducted during 1989 rainy season through summer 1990 to study the influence of seasons on growth and yield of sunflower cultivars (SS-56; Morden; EC-68415; SH-7; BSH-1 and KBSH-1). Results indicated that all the cultivars were early in flowering during rainy season (51.7 to 60.7 days) compared to other seasons (54.0 to 69.3 days in post-rainy season and 57.3 to 69.3 days in summer). The number of filled seeds per head and seed filling percentage were high in summer compared to rainy and post-rainy seasons. The highest seed yield of 24.5 q/ha was recorded in 'KBSH-1' grown during summer. However the highest per se oil content and oil yield was observed in BSH-1 and KBSH-1, respectively.

Key words : Cultivars, oil content, seasons, seed yield, sunflower.

INTRODUCTION

Inspite of fluctuations in the area and production in the past two decades, sunflower has been established as an important oilseed crop in the country. Currently, Karnataka and Maharashtra states account for 85 per cent of the area and 65 per cent of production. The area under this crop is spreading rapidly and gaining popularity even in non-traditional parts of country due mainly to its short growth period coupled with photo-period insensitivity which enables its cultivation in any season. Other advantages in cultivation of sunflower are its wide adaptability to different agro-climatic regions and soil types, easy cultivation and crop management and low seed rate (5 kg/ha) with high seed multiplication ratio. However, the productivity has been substantially low (600 kg/ha) owing to poor seed setting which is supposed to be controlled by both internal and external factors (Kathiresan and Ramaswamy, 1978). Unlike other crops, seed development and maturation in sunflower is largely influenced by seasonal factors. Although sunflower is regarded as a photo insensitive crop, the GxE interaction has been widely prevalent. It is, therefore, imperative to identify specific varieties/hybrids, suitable to different crop growing seasons in a given location.

MATERIALS AND METHODS

A field experiment was conducted during rainy season and post-rainy season of 1989 and summer of 1990 at GKVK, UAS, Bangalore. The soil of the experimental site was red sandy clay loam with slightly acidic pH (6.4) normal electrical conductivity (0.19 to 0.20 ds/m), low available nitrogen (209 to 218 kg/ha), medium content of available P_2O_5 (16.40 to 17.39 kg/ha), available K_2O (138 to 152 kg/ha) and organic carbon (0.53 to 0.58%). Three open pollinated varieties viz., SS-56, Morden and EC-68415 and three hybrids viz., SH-7, BSH-1 and KBSH-1 were included in the study. The crop was sown on 21st July in rainy season, 1989, on 9th November in post-rainy season 1989 and on 31st January in summer 1990. The experiment was laid out in Randomised Block

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Design with four replications. Gross plot size was 3.6m x 3.0m (10.8 m^2) with 6 rows and 10 plants in each row planted at a spacing of 60 cm x 30 cm. A week after emergence of seedlings, thinning was done to maintain one plant per hill. Two hand weedings were done after 20 and 40 days after sowing. Earthing up was done when the crop was 35 days old. Plants in the net plot (3.6m x 1.8m) were harvested separately when the back of the heads turned to lemon yellow colour. Seeds were separated from well dried heads by gently beating with a stick and then cleaned and yield per plot was recorded. Days to 50%flowering was recorded when 50 per cent of plants in each treatment flowered. Well filled seed of the labelled heads were counted and averaged out to get mean number of filled seeds per head. Percentage of filled seeds per head was worked out by dividing the number of filled seeds per head by total number of seeds and multiplied by 100. Volume weight was recorded by filling the seeds into a 100 cc measuring jar completely and its weight was recorded in grams. Seed density was found out by filling the density cup having perforation with a gram of seeds and then the cup was immersed in the beaker containing known volume of water. The initial and final volume of water in the beaker was recorded and seed density was calculated by dividing weight of seeds by volume of water displaced in the beaker after immersion and expressed in g/cc. Achene oil content was determined using Nuclear Magnetic Resonance spectometer (NMR-Model, Braker Minispec 20 pi). Oil yield per plot was computed by multiplying achene oil content (%) by seed yield per hectare.

RESULTS AND DISCUSSION

Growth and yield components

Data on days taken to 50 per cent flowering were found significant for cultivars as well as for seasons and their interaction (Table 1). Among cultivars, EC-68415 took more number of days for 50 per cent flowering (66.4) compared to SS-56 which took 54.3 days. With regard to seasons, late flowering was observed during summer (63.7 days) compared to post-rainy (62.6 days) and rainy seasons (57,4 days). Cultivars such as EC-68415 and hybrid SH-7 were found to take the same number of days for 50 per cent flowering both in post-rainy (69.3 and 67.3 days, resp.) and summer seasons (69.3 and 67.5 days, resp.). Other cultivars and hybrids had differences in flowering in different seasons although the trend remained the same. Significant differenceses in number of filled seeds per head were observed among the cultivars, seasons and their interactions. Hybrid KBSH-1 recorded the highest number of seeds (803) and the lowest being in SS-56 (588). Summer grown sunflower had highest number of seeds (765) and it was lowest in rainy season (646). With regard to interactions, KBSH-1 had highest (740) and Morden had the lowest number of seeds in rainy season (505). During post-rainy season, SH-7 had maximum (820) and SS-56 the lowest (653). Hybrids were found to have better seed filling percentage (84.5 to 86.3%) than cultivars (75.4 to 78.0% . Season had a profound influence on this character with the highest percentage found in summer (84.6%) compared to rainy (79.3%) and post-rainy seasons (79.7%). In rainy and summer seasons KBSH-1 had the highest percentage (83.5 and 89.5% resp.), while SH-7 had the highest in post-rainy season (86.4%). Studies carried out by Choudhary and Anand (1987) also showed high seed set during summer season compared to rainy and post-rainy season.

Seed Quality parameters

Seeds produced in post-rainy season were found to have the highest test weight, seed density and volume weight (Table 2). It ranged from 60.0 to 73.7 g in post-rainy season and from 57.3 to 67.2 g in summer. Cultivars EC-68415 had highest test weight (69.9g) and seed density (0.466 g/cc), while BSH-1 recorded highest volume weight. Seed density varied from 0.315 to 0.408 g/cc in rainy season, from 0.418 to 0.519 g/cc in post-rainy and from 0.354 to 0.473 g/cc in summer in SS-56 and EC-68415, respectively. Maximum volume weights of 35.9 g in rainy season, 44.7g in post-rainy season and 41.3 g in summer were found with BSH-1, KBSH-1 and KBSH-1, respectively. Increase in test weight during post-rainy season could be attributed to the effect of compensation mechanism, where in less number of seeds compensated for better seed development and increased weight. Roath and Miller (1982) and Krishnegowda (1983) also explained compensatory effect on yield with fewer number of filled seeds per capitulum recording high seed weight. The reduction in test weight during rainy season might be due to lower translocation of photosynthesis and lesser accumulation of carbohydrates (Bhattacharya, *et al.*, 1983). Also prolonged vegetative growth of crop might have resulted in formation of heavier seeds during post-rainy and summer seasons.

Seed yield, oil content and oil yield

Seed yield per hectare, achene oil content and oil yield per hectare differed significantly due to cultivars as well as seasons and their interactions (Table 3). Maximum seed yield of 22.1 q/ha and oil yield of 903 kg/ha were obtained in hybrids SH-1 and KBSH-1, respectively. However, EC-68415 was found to have the highest oil content of 55.4 per cent. Seed yield (20.8 q/ha), oil content (41.1%) and oil yields (858 kg/ha) were found to be higher in summer than in other seasons. Among hybrids, KBSH-1 gave maximum yield of 18.9 and 24.5 q/ha in rainy summer seasons, respectively, while SH-7 had provided the highest yield in post-rainy season (23.4 q/ha). The per cent oil content in achene was significant among cultivars. Highest oil content in achene was recorded in KBSH-1 (41.1%) followed by EC-68415 (40.5%), while other cultivars had oil content on par with each other. The oil content was significantly higher in summer (41.1%) than in rainy season (32.5%), but was on par with oil content in post-rainy season. Highest oil yield of 659 kg/ha in rainy season, 950 kg/ha in post-rainy season and 1101 kg/ha in summer were obtained from KBSH-1. High temperature, bright sunshine hours and prolonged day length during flowering and seed development stage have been reported to be positively correlated with oil content (Habeebullah *et al.*, 1983). In the present study, higher seed and oil yields of KBSH-1 could be attributed to higher number of filled seeds per head, seed filling percentage and oil content during summer season. Hence, it can be concluded that for maximum production and productivity of sunflower in Bangalore condition, KBSH-1 was found suitable for cultivation in summer.

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Table 1 . Days to 50% flowering, filled seeds/head and seed filling (%) in sunflower cultivars in different seasons.

Cultivars	Days to 50% flowering				Number of filled seeds/head				Seed filling (%)			
	Rainy	Post rainy	Summer	Mean	Rainy	Post rainy	Summer	Mean	Rainy	Post rainy	Summer	Mean
'SS56'	51.7	54.0	57.3	54.3	623	489	653	588	75.9	70.4	79.8	75.4
'Morden'	55.0	58.5	59.7	57.4	505	619	663	595	75.0	77.4	79.3	77.2
'EC68415'	60.7	69.3	69.3	66.4	657	594	762	671	78.5	72.7	82.8	78.0
'SH7'	59.3	67.3	67.5	64.7	677	826	861	788	81.4	86.4	89.1	85.6
'BSH1'	58.0	60.7	62.5	60.4	678	736	777	730	81.4	85.2	86.9	84.5
'KBSH1'	59.5	65.7	66.7	64.0	740	792	879	803	83.5	86.0	89.5	86.3
Mean	57.4	62.6	63.7		646	675	765		79.3	79.7	84.6	
	Seasons	Cultivars	Interaction		Seasons	Cultivars	Interaction		Seasons	Cultivars	Interaction	
CD (P=0.05)	0.888	1.260	2.180		35.88	50.76	87.83		1.480	2.080	3.610	

Table 2 . Influence of season on test weight, seed density and volume weight of sunflower cultivars.

Cultivars	Test weight (g/1000 seeds)				Seed density (g/cc)				Volume weight (g)			
	Rainy	Post rainy	Summer	Mean	Rainy	Post rainy	Summer	Mean	Rainy	Post rainy	Summer	Mean
'SS56'	56.4	61.4	57.7	58.5	0.315	0.418	0.354	0.362	29.1	37.5	35.2	33.9
'Morden'	50.6	60.1	57.6	56.1	0.341	0.446	0.359	0.382	29.2	36.7		
'EC68415	69.0	73.7	67.2	69.9	0.408	0.519	0.473	0.466	35.5	42.5	40.4	39.5
'SH7'	58.0	66.9	63.5	62.8	0.329	0.481	0.388	0.399	29.4	39.6	37.3	35.4
'BSH1'	51.5	60.0	57.3	56.3	0.381	0.460	0.410	0.417	35.9	43.8	40.8	40.2
'KBSH1'	50.9	62.8	61.4	58.4	0.377	0.494	0.445	0.438	33.7	44.7	41.3	39.8
Mean	56.1	64.1	60.8		0.358	0.469	0.405		32.1	40.8	37.9	
	Seasons	Cultivars	Interaction		Seasons	Cultivars	Interaction		Seasons	Cultivars	Interaction	
CD (P=0.05)	0.719	1.020	1.760		0.006	0.009	0.015		1.540	2.170	NS	

Table 3. Seasonal influence on seed yield, oil content and oil yield of sunflower cultivars

Cultivars	Seed yield (q/ha) Rainy	Seed yield (q/ha) Post rainy	Seed yield (q/ha) Summer	Seed yield (q/ha) Mean	Oil content (%) Rainy	Oil content (%) Post rainy	Oil content (%) Summer	Oil content (%) Mean	Oil Yield (kg/ha) Rainy	Oil Yield (kg/ha) Post rainy	Oil Yield (kg/ha) Summer	Oil Yield (kg/ha) Mean
'SS56'	15.0	12.9	16.2	14.7	31.5	38.8	40.4	36.9	473	500	655	543
'Morden'	13.5	15.6	17.2	15.4	30.8	38.8	39.0	36.2	415	606	668	563
'EC68415'	18.4	19.3	21.9	19.9	34.3	43.5	43.8	40.5	631	836	961	810
'SH7'	18.8	23.4	23.9	22.1	30.9	37.3	39.9	36.0	581	872	957	803
'BSHI'	16.3	19.3	20.8	18.8	32.8	36.9	38.8	36.2	538	713	806	685
'KBSHI'	18.9	21.7	24.5	21.7	34.8	43.7	44.9	41.1	659	950	1101	903
Mean	16.8	18.7	20.8		32.5	39.8	41.1		549	746	858	

	Seed yield Seasons	Seed yield Cultivars	Seed yield Interaction	Oil content Seasons	Oil content Cultivars	Oil content Interaction	Oil yield Seasons	Oil yield Cultivars	Oil yield Interaction
CD(P=0.05)	0.898	1.040	1.390	1.580	2.000	NS	31.38	40.76	64.28

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AVAILABILITY AND UPTAKE OF NITROGEN BY SUNFLOWER AND UREASE ACTIVITY IN SOIL DUE TO CYTOZYME APPLICATION

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ABSTRACT

A field experiment was conducted during summer and *Kharif* seasons of 1995 to study the effect of Cytozyme on urease activity in soil and availability and uptake of nitrogen by sunflower. The urease activity decreased significantly with increasing doses of cytozyme granules. The combined application of granules and foliar spray of cytozyme did not show any additional improvement. The availability of nitrogen and the uptake of the same by sunflower increased significantly due to cytozyme application.

Key Words: Sunflower; Cytozyme; urease activity; N uptake

INTRODUCTION

Cytozyme is a biologically derived plant growth promoter. It is a heterogeneous protein digest extract, enriched with biologically activated micronutrients like zinc, iron and copper and is found to increase the physiological activity. The product is available in four formulations, ie., seed plus, crop plus, soil plus and granules; the last one being the new formulation introduced into the market for spray-shy crops.

Urea is the most important nitrogenous fertilizer in world agriculture today. It's rapid hydrolysis to ammonia and CO_2 through soil urease activity leads to a rise in pH in its immediate vicinity followed by severe losses of ammonia through volatilization (Rao and Batra, 1983). High concentrations of ammonium nitrogen and high pH inhibit the activity of nitrite oxidizing bacteria resulting in an accumulation of nitrite, which may cause damage to germinating seedlings (Court *et al.*, 1962). It has been suggested that fertilizer urea would be used more efficiently if urease activity in soil is inhibited long enough to allow the urea to be washed into the soil (Cooke, 1964).

The effect of cytozyme as a urease activity inhibitor has been reported in recent times and its effect is similar to the other growth regulators (Rao and Ghai, 1986). Only a little information is available on the performance of cytozyme in influencing the activity of urease and, hence, the present investigation was carried out to study the effect of cytozyme granules on the urease activity in soil, availability and uptake of nitrogen by sunflower crop.

MATERIALS AND METHODS

Field experiments were conducted at the Agricultural Research Station, Bhavanisagar during summer and *Kharif* seasons of 1995. The soil of the fields is sandy loam in texture with available N of 173.8 and 216 kg ha^{-1} available P of 13.0 and 16 kg ha^{-1}; available K of 230 kg ha^{-1} and with pH of 6.9 and 7.5 during summer and *Kharif* seasons, respectively. The experiments were laid out in a randomised block design with eight treatments (cytozyme granules alone applied at 6,12 and 18 kg ha^{-1} levels and in combination with foliar spray of cytozyme at a concentration of 0.05 per cent), each replicated four times.

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Sunflower (Var.Morden) was raised as the test crop. Summer crop was sown during April, 1995 and was harvested during June, 1995, while the *Kharif* crop was sown during July, 1995 and was harvested during September, 1995. Crop management practices were carried out uniformly to all the plots. Recommended dose of N P and K at the rate of 40:20:20: kg ha^{-1} in the form of urea, diammonium phosphate and muriate of potash was supplied to all the plots. cytozyme granules applied to the soil as per the treatment schedule were incorporated and cytozyme crop plus was sprayed in the concerned plots at 30 days after sowing (DAS) with a spray volume of 450 l ha^{-1}. The urease activity in soil was estimated at three stages of crop growth viz., at 45 DAS, 70 DAS and at harvest by adopting standard methods (Tabatabai and Bremner 1972).

RESULTS AND DISCUSSION

Significant reduction in urease activity due to cytozyme application was observed during both the seasons. In all the three stages of crop growth the treated plots recorded reduced urease activity which was significantly lower than the activity observed in control plots. With increasing dose of granules, there was significant reduction in urease activity; the reduction being 30.8 and 35.3 per cent compared to control in summer and *Kharif* seasons respectively when applied at 18 kg ha-1.

Combined application of granules and foliar spray of cytozyme at any level was not better than the application or corresponding granular form alone. Similar results were recorded at 70 DAS and at harvest also. The results are in accordance with the findings reported by Rao and Ghai (1986) and Thiageswari (1991) in soybean.

It could be deduced that increasing the dose of cytozyme application reduced the urease activity in soil, which in turn reduced the hydrolysis of applied urea resulting in the release of nitrogen in a phased manner as evidenced by the significant increase in available nitrogen with increasing doses of cytozyme as soil application. (Table 2) however in *Kharif* the increase in available N alone 12 kg ha^{-1} (i.e. at 18 kg ha^{-1}) was not significant. Correspondingly uptake of N increased with increasing rates of cytozyme. However increase in N uptake at 18 kg ha^{-1} cytozyme granules was on par with that at 12 kg ha^{-1} at all the stage of observation during summer and at 70 DAS and at harvest in *Kharif* (Table 3). The combined application of foliar spray and granules did not prove to be of any advantage. Similar trend was also observed in the uptake of nitrogen. The investigation indicated that cytozyme has promise for conserving urea N by inhibiting the urease activity in soil.

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Table 1: **Effect of cytozyme on urease activity (ug NH_4^+ -N g^{-1} of soil 2 h^{-1}) at different stages of crop growth.**

Treatments	Summer Sunflower			Kharif Sunflower		
	45 DAS	70 DAS	Harvest stage	45 DAS	70 DAS	Harvest stage
Control	357	200	163	216	110	117
Cg at 6 kg ha^{-1}	315	168	149	194	88	107
Cg at 12 kg ha^{-1}	292	156	145	154	75	97
Cg at 18 kg ha^{-1}	273	155	137	140	70	89
Cs at 0.05 per cent	317	163	145	189	100	108
Cg at 6 kg ha^{-1} Cs at 0.05% per cent	301	159	128	144	83	111
Cg at 12 kg ha^{-1} + Cs at 0.05 per cent	254	150	118	150	77	95
Cg at 18 kg ha^{-1} + Cs at 0.05 per cent	246	154	114	161	71	82
CD(p=0.05)	50.2	28.9	26.5	25.8	13.1	24.3

Cg = Cytozyme granules, Cs = Cytozyme spray

Table 2 : **Effect of cytozyme on the availability of nitrogen (kg/ha) at different stages of crop growth**

Treatments	Summer Sunflower			Kharif Sunflower		
	45 DAS	70 DAS	Harvest stage	45 DAS	70 DAS	Harvest stage
Control	174	200	209	216	226	205
Cg at 6 kg ha^{-1}	183	212	212	217	272	223
Cg at 12 kg ha^{-1}	189	250	215	246	289	235
Cs at 18 kg ha^{-1}	222	276	242	200	282	235
Cs at 0.05 per cent	218	260	258	221	253	235
Cg at 6 kg ha^{-1} + Cs at 0.05 per cent	181	237	262	246	239	221
Cg at 12 kg ha^{-1} + Cs at 0.05 per cent	180	232	247	223	240	219
Cg at 18 kg ha^{-1} + Cs at 0.05 per cent	179	253	209	213	217	223
CD(p=0.05)	20	33	19	22	21	24

Cg = Cytozyme granules, Cs = Cuytozyme spray

Table 3 : Effect of cytozyme on N uptake (kg/ha) at different stages of crop growth.

Treatments	Summer Sunflower				Kharif Sunflower			
	45 DAS	70 DAS	Harvest stage		45 DAS	70 DAS	Harveststage	
			Seed	Stover			Seed	Stover
Control	11.48	16.05	12.58	20.55	12.60	16.98	12.65	21.70
Cg at 6 kg ha^{-1}	12.95	18.10	14.13	26.88	12.70	19.63	16.53	23.40
Cg at 12 kg ha^{-1}	14.88	21.13	14.83	34.53	13.80	21.10	19.78	27.08
Cg at 18 kg ha^{-1}	15.20	20.95	15.58	28.15	13.30	19.80	19.65	25.40
Cs at 0.05 per cent	11.48	17.75	12.33	29.13	13.30	17.05	13.18	24.80
Cg at 6 kg ha^{-1} + Cs at 0.05 per cent	13.88	21.20	18.88	32.55	13.40	20.68	18.88	29.10
Cg at 12 kg ha^{-1} + Cs at 0.05 per cent	15.28	21.48	18.35	37.23	12.70	21.93	19.73	29.55
Cg at 18 kg ha^{-1} + Cs at 0.05 per cent	13.20	21.63	19.33	30.80	12.80	21.68	20.05	27.90
CD (p=0.05)	1.56	2.68	2.79	7.02	NS	1.36	1.06	3.61

Cg = Cytozyme granules, Cs = Cytozyme spray

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EFFECT OF MOISTURE CONSERVATION PRACTICES AND TIME OF NITROGEN APPLICATION ON YIELD OF CASTOR

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ABSTRACT

Studies were conducted at Regional Agricultural Research Station, Palem during *Kharif*, 1993 and 1994 on shallow alfisols with 1 to 2% slope on the effect of different moisture conservation practices and time of nitrogen application on yield of castor under rainfed conditions. Sowing along the contour and making ridges and furrows at 30 - 35 DAS in conjunction with application of 20 kg nitrogen gave substantially higher yield and Increment benefit cost ratio. Split application of 40 kg N (20 kg basal and 20 kg at 30 - 35 DAS) increased the nitrogen use efficiency by 64% in terms of seed yield.

Key words : Castor, moisture conservation practices, time of nitrogen application.

INTRODUCTION

In India, though Andhra Pradesh occupies 34% of total castor area (0.79 m ha) contributes only 10.6% of total production (0.85 mt). In Andhra Pradesh, castor is predominantly grown in Southern Telengana Zone to an extent of 0.26 m ha with a production of 0.08 m t.

In Southern Telangana Zone, castor is mainly cultivated on undulating lands which are largely red chalka soils with low fertility and moisture retentivity and are more prone for erosion also. Castor grown on these rolling lands under rainfed conditions is subjected to drought during dry period and to erosion due to heavy rains, during the same season. Non-adoption of soil and moisture conservation practices on these lands is the main reason for low productivity.

Castor with fast developing and deep penetrating tap root system is drought tolerant but responds to favourable moisture and nutrient supply. However, research on the effect of moisture conservation practices in castor is sporadic.

Hence, to increase the efficiency of applied nitrogen through moisture conservation practices, studies were undertaken at Regional Agricultural Research Station, Palem during Kharif, 1993 and 1994.

MATERIALS AND METHODS

The studies were conducted on shallow alfisols with 1 to 2% slope. The soils were neutral in reaction and sandy loam in texture. Available nitrogen in soil was low, phosphorus and potassium were high and low in organic carbon.

The experiment was laid out in a split plot design in four replications. The main treatments were moisture conservation practices viz., M1: sowing across the slope, M2: sowing along the contour, M3: M2 + dead furrow after every row at 30-35 DAS and M4: M2 + ridge and furrow at 30-35 DAS.

Dead furrow : Along the contours furrows of 15 cm depth were opend between rows at 30-35 DAS with country plough.

Ridges and furrows : Between the plant rows ridges and furrows were formed at 30-35 DAS with ridge plough along the contours.

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The sub treatments were time and levels of nitrogen application, viz., NO, N1 (40 kg/ha) : all as basal and N2 (40 kg/ha): 20 kg basal + 20 kg at 30-35 DAS. A uniform dose of 40 kg P_2O_5 and 30 kg K_2O was applied to all the treatments. Aruna, a popular local variety was tested with a spacing of 90 x 30 cm. The gross plot size was 9.0 x 7.2 m. Data on number of effective spikes and test weight (g/100 seed) were recorded. Harvesting was done at 90 and 120 DAS.

Nitrogen use efficiency was expressed interms of increase in seed yield per kg of N applied.

Increment Benefit cost ratio (IBCR)

Increment benefit cost ratio was computed through partial budgeting technique by taking into consideration the additional cost incurred due to imposition of the treatments and the additional returns realised and was expressed in rupees.

RESULTS AND DISCUSSION

Sowing along the contour and making ridges and furrows at 30-35 DAS gave more number of effective spikes (Table. 1) compared to other treatments during 1993, while during 1994, sowing along the contour with ridges and furrows or opening dead furrows at 30-35 DAS or sowing along the contour only, gave more number of effective spikes over sowing across the slope. Application of 40 kg nitrogen in two splits (20 N basal + 20 N at 30 - 35 DAS) gave more number of effective spikes during both the years of study. Interaction was significant during 1993.

Sowing along the contour and making ridges and furrows or opening dead furrows at 30-35 DAS gave more test weight compared to the other methods of moisture conservation during both the years due to more number of effective spikes and test weight. Similar trend was also observed in pooled yield. The possible reason is formation of ridges and furrows might have increased the porosity, hydraulic conductivity and infiltration rate resulting in better availability of moisture and nutrients which cumulatively reflected in higher yield (ICRISAT, 1976 and Anonymous, 1984).

Split application of 40 kg N, half as basal and half at 30-35 DAS, gave more yield than application of 40 kg N in a single dose.

The interaction effect on pooled yield of 1993 and 1994 (Table 2.), indicated that sowing along contour coupled with ridges and furrows at 30-35 DAS in conjunction with application of 20 kg N/ha gave 141% more yield compared to sowing across the slope, due to production of more seed yield of castor per kg of nitrogen applied (Table 3). The increase in yield in this treatment can be attributed to availability of more moisture and less erosion in ridges and furrows. The furrows might have acted as micro watersheds in storing the rain water and helped in better utilization of applied nutrients by the crop. Similar observations were made by Reddy *et al.* (1977), Umadevi *et al.* (1991) and Prasad *et al.* (1993). Thus, the ridges and furrows accelerated adequate percolation of water and conserved moisture in the root zone for better utilization of water as opined by panwar and Singh (1976).

The data (Table 3.) further indicated that application of 40 kg nitrogen in two splits (20 kg basal + at 30-35 DAS) increased nitrogen use efficiency by 64% and produced 4.3 kg of more castor seed per kg of nitrogen applied than applying entire 40 kg N in single dose as basal.

Sowing across the slope resulted in lowest yield which may be due to less water storage, low water use efficiency and nutrient uptake. Prasad *et al.* (1993), reported that soil erosion and loss of rain water were more in up and down cultivation than contour cultivation resulting in lower yields.

Among the different treatments, making ridge and furrow at 30-35 DAS coupled with split application of 40 kg N/ha resulted in more IBCR (4.2) followed by ridge and furrow with 40 kg N/

ha in single dose as basal (3.6) only (Table4.), due to more yield.

Thus, making ridge and furrow at 30-35 DAS coupled with application of 20 kg N/ha increased castor yields on rolling lands, under rainfed conditions.

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Table 1. Effect of moisture conservation practices and time of nitrogen application on yield attributes and yield.

Treatments	Effective spike number		Test weight (g)		Total seed yield (kg/ha)	
	1993	*1994*	*1993*	*1994*	*1993*	*1994*
Moisture conservation practices (M)						
M1 : Sowing across the slope	5.6	5.8	15.9	15.5	591	418
M2 : Sowing along the contour	5.9	6.2	16.4	15.9	746	748
M3 : M2+dead furrow after every row at 30-35 DAS	6.4	6.7	16.6	16.3	914	908
M4 : M2+ ridge and furrow at 30-35 DAS	7.9	6.8	16.8	16.6	1052	1339
SEm±	0.13	0.26	0.11	0.17	10.3	36.5
CD5%	0.29	0.83	0.34	0.54	33	117
Time of nitrogen application (N)						
No : No nitrogen	5.5	5.8	16.0	15.7	605	598
N1 : 40 kg/ha (all basal)	6.5	6.3	16.5	16.2	863	874
N2 : 40 kg/ha (1/2 basal+ 1/2 30-35 DAS)	7.2	6.9	16.7	16.3	1009	1073
SEM±	0.10	0.19	0.21	0.14	13.2	26.7
CD 5%	0.30	0.55	NS	0.41	39	78
Interaction M X N						
SEm±	0.20	0.37	0.42	0.28	24.6	53
CD 5%	0.62	NS	NS	NS	77	166

Table 2. Effect of different soil and moisture conservation practices on pooled (1993 & 1994) yield (kg/ha) of castor

Moisture conservation practice	Nitrogen levels (kg/ha)			
	No	N40*	N40**	Mean
M1 sowing across slope	382	502	628	505
M2 sowing along contour	586	740	885	737
M3 M2 + dead furrow after every row at 30-35 DAS	652	948	1131	910
M4 M2 + ridge and furrow at 30-35 DAS	785	1283	1517	1195
Mean	602	868	1040	837
	Moisture conservation Parctices		'N' levels	Interaction
SEm±	18.5		15.1	42.5
CD 5%	53		43	122

*N40-all basal **N40-1/2 basal + 1/2 at 30-35 DAS

Table 3: Effect of moisture conservation practices and time of application of N on nitrogen use efficiency (kgseed/kg N)..

Moisture conservation practice	Nitrogen level (kg/ha)		
	N_{40} (all basal)	N_{40} (1/2 basal+1/2 at 30-35 DAS)	Mean
M1 : Sowing across slope	3.0	6.2	4.6
M2 : Sowing along contour	3.9	7.5	5.7
M3 : M2 + dead furrow after every row at 30-35 DAS	7.4	11.9	9.7
M4 : M2 + ridge and furrow at 30-35 DAS	12.5	18.3	15.4
Mean	6.7	11.0	8.9

Table 4: Increment benefit cost ratio (IBCR)

Moisture conservation practice	Nitrogen (kg/ha)			
	No	N4 0 (All-basal)	N4 0 (1/2 basal +1/2 at 30-35 DAS)	Mean
M1 : sowing across slope	1.1	1.4	1.9	1.5
M2 : sowing along contour	1.7	2.0	2.5	2.1
M3 : M2 + dead furrow after every row at 30-35 DAS	1.8	2.6	3.1	2.5
M4 : M2 + ridge and furrow at 30-35 DAS	2.1	3.6	4.2	3.3
Mean	1.7	2.4	2.9	2.4

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EFFECT OF IRRIGATION AND NITROGEN ON YIELD AND QUALITY OF LINSEED (*Linum Usitatissimum* L.)

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ABSTRACT

In a 2-year experiment, 90 Kg N/ha and 4 irrigations each of 6 cm based on 0.8 irrigation water to commulative pan evaporation ratio resulted in maximum number of capsules/plant, number of seeds/capsule, 1000 - seed weight, seed and straw yield per unit area of 'Garima' linseed grown on a silty loam soil. The oil content decreased with increase in levels of irrigation and nitrogen. However, moisture regimes did not affect the protein content in grain significantly.

Key words : Irrigation, Nitrogen, oil content, yield, linseed.

INTRODUCTION

Linseed has got special importance amongst the oilseed crops because of its industrial value. The average seed yield is 267 kg/ha which is very low. The reasons for the low yield of linseed are basically its under fertilization and restricted or no irrigation. Improvement in yields can be brought about by suitable irrigation schedule (Pandey *et al.*, 1970) and nitrogen fertilization (Tomar *et al.*,1985) for linseed crop.

MATERIALS AND METHODS

The experiment was conducted at the research farm of Narendra Deva University of Agriculture and Technology, Faizabad(U.P.) during the Rabi 1990-92. The experiment was laid out in a 4-replicated split-plot design keeping irrigation schedules in main plot and nitrogen levels in sub-plots. The irrigations based on irrigation water/cumulative pan evaporation (IW/CPE) ratio of 0.4, 0.6, and 0.8 were scheduled alongwith rainfed control. Each time 60 mm water was applied. The number of irrigations given during both the years in IW/CPE ratio of 0.4, 0.6 and 0.8 were 2,3 and 4, respectively (Table 1). Nitrogen as urea was applied @ 0,30,60, and 90 kg/ha. Half of the N and a common dose of 30 kg/ha each of P_2O_5 and K_2O were placed about 10 cm deep in the furrows. The remaining half of nitrogen was top dressed at the time of first irrigation. The variety used was 'Garima' (LHCK-39). The soil of the experimental plot was silty loam in texture and during 1990-91 contained 220.52 kg N/ha, 19.08 kg P/ha, 256.10 kg k/ha with a pH of 8.14 and in 1991-92 had 230.50 kg N/ha, 18.25 kg p/ha and 260.76 kg K/ha with a pH of 8.12. The oil content was determined as per AOAC (1970), while protien in grain was estimated as per Loomis and Shull (1937). The crop was sown on 22 and 16 November in 1990 and 1991, respecitively using 25 kg/ha seed. A presowing irrigation was given to facilitate germination. Thereafter, irrigations were applied as per the cumulative pan evaporation. The crop was harvested on 3 April, 1991 and 25 March, 1992.

RESULTS AND DISCUSSION

Effect of irrigation schedule:

Irrigation schedule based on IW/CPE ratio of 0.8 gave the maximum number of capsules/plant and

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CPE ratio of 0.8 was significantly higher than other ratios and rainfed treatment. An increase in the moisture regime resulted in a significant reduction in oil content of seed, but the differences were not significant in case of protien content (Table 2). Increase in seed yield of linseed due to irrigation water might be due to the fact that water helped in better utilization of nutrients in the soil. Moreover, the above mentioned yield attributing characters have positive association with the seed yield of linseed as reported by Gupta and God awat (1981).

Effect of nitrogen Levels:

Nitrogen at increasing rates resulted in the production of superior yield attributes viz., number of capsules/plant, number of seeds/capsule and 1000- seed weight which ultimately enhanced the seed production significantly (Table 2). Singh *et al.* (1982) also reported increase in linseed grain yield due to nitrogen application. The oil content in the seed decreased significantly with successive doses of nitrogen upto the highest dose of 90 kg/ *et al.* (1988). Nitrogen fertilization significantly increased the protein content of linseed grain upto the level of 60 kg/ha. Further increase had no significant effect. Nitrogen is a fundamental structural unit of protein. Hence, more the nitrogen supply, more will be the formation of amides, aminoacids and subsequently the proteins, as also reported by Singh and Singh (1978) and Nayital and Singh (1984).

Effect of irrigation schedule Xnitrogen levels:

The interaction of irrigation frequency and nitrogen was found to be significant for 1000-seed weight, seed yield and straw yield in both the years (Table 3). During both the years, consistently higher response to irrigation was observed in the presence of nitrogen. The highest 1000- seed weight, seed yield and straw yield were obtained at 0.8 IW/CPE ratio along with 90 kg N/ha closely followed by 60 kg N/ha under same level of irrigation, while lowest values were noted under the rainfed and no nitrogen combination. The trend was similar during both the years. This

Table 1: Irrigation schedule, Number of irrigations and total quantity of water (including rains) received by linseed at Faizabad.

	1990-91			1991-92		
	IW/CPE ratio					
	0.4	0.6	0.8	0.4	0.6	0.8
	3 Feb. 16 Mar.	12 Jan 17 Feb 16 Mar.	24 Dec. 3 Feb. 22 Feb. 16 Mar.	11 Jan. 4 Mar.	14 Dec. 6 Feb. 4 Mar.	7 Dec. 11 Jan. 16 Feb 4 Mar.
Amount of water (mm)	120	180	240	120	180	240
Rains during crop season (mm)	33	33	33	29	29	29
Total	153	213	273	149	209	269

From the foregoing account it can be concluded that scheduling of irrigation at 0.8 IW/CPE (4 irrigations of 60 mm each) should be used along with 90 kg N/ha for obtaining higher yield of linseed crop under eastern U.P. conditions.

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Table 2: **Effect of irrigation and nitrogen levels on yield and quality of linseed (pooled data of 1990-91 and 1991-92)**

Treatments	No. of capsules/plant	No of seeds/capsule	1000-seed weight (g)	Seed yield (q/ha)	Straw yield (q/ha)	Oil content (%)	Protein content (%)
Irrigation (IW/CPE)							
Rainfed	27.3	7.8	7.99	5.72	7.33	40.15	19.62
0.4	31.0	8.4	8.12	6.90	8.46	39.76	19.72
0.6	34.8	8.5	8.20	7.64	9.18	39.34	20.04
0.8	36.5	8.7	8.30	8.73	10.48	39.98	20.20
SEm+_	0.57	0.06	0.005	0.07	0.06	0.05	0.18
CD (0.05)	1.82	0.20	0.015	0.22	0.20	0.17	NS
Nitrogen (Kg/ha)							
0	27.3	7.8	8.01	5.94	7.46	40.88	18.79
30	31.9	8.2	8.12	6.97	8.47	39.84	19.70
60	34.8	8.5	8.20	7.79	9.55	39.20	20.35
90	36.1	8.6	8.27	8.31	9.97	38.46	20.59
SEm ±	0.32	0.09	0.004	0.06	0.09	0.03	0.09
CD (0.05)	0.93	0.25	0.011	0.19	0.26	0.10	0.26

Table 3 . Effect of irrigation Xnitrogen levels on test weight, grain and straw yields of linseed

Irrigation (IW/CPE)	1000-seed weight (g) 0	30	60	90	Mean	Grain yield (q/ha) 0	30	60	90	Mean	straw yield (q/ha) 0	30	60	90	Mean
							Nitrogen (kg/ha)								
							1990-91								
Rainfeed	8.00	8.07	8.12	8.16	8.08	4.47	5.52	6.30	6.47	5.69	6.12	6.90	8.05	8.25	7.33
0.4	8.10	8.19	8.25	8.35	8.22	6.05	6.57	7.32	7.45	6.84	7.55	8.62	8.80	8.92	8.47
0.6	8.14	8.27	8.38	8.50	8.32	6.32	7.45	7.95	8.70	7.60	7.92	9.02	9.77	10.47	9.29
0.8	8.24	8.39	8.54	8.63	8.45	6.82	8.02	9.02	9.82	8.42	8.15	9.15	11.27	11.95	10.13
Mean	8.12	8.23	8.32	8.41		5.91	6.89	7.65	8.11		7.43	8.42	9.47	9.89	
		SEm±		CD (0.05)			SEm±		CD (0.05)			SEm±		CD (0.05)	
N at same I		0.01		0.03			0.29		0.81			0.23		0.64	
I at same N		0.02		0.04			0.35		1.04			0.28		0.83	
							1991-92								
Rainfed	7.81	7.86	7.93	7.96	7.89	4.50	5.62	6.42	6.55	5.77	6.07	7.25	7.90	8.12	7.33
0.4	7.89	7.98	8.07	8.12	8.01	6.10	6.67	7.40	7.60	6.94	7.55	8.15	9.02	9.15	8.46
0.6	7.91	8.03	8.13	8.21	8.07	6.37	7.50	8.02	8.77	7.66	7.85	9.07	9.45	9.95	9.08
0.8	7.99	8.12	8.22	8.26	8.14	6.90	8.30	9.85	11.12	9.04	8.47	9.70	12.22	12.95	10.83
Mean	7.90	7.99	8.08	8.13		5.96	7.02	7.92	8.51		7.48	8.54	9.64	10.04	
		SEm±		CD (0.05)			SEm±		CD (0.05)			SEm±		CD (0.05)	
N at same I		0.01		0.03			0.23		0.67			0.30		0.85	
I at same N		0.02		0.05			0.23		0.68			0.28		0.82	

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STUDIES ON WEED MANAGEMENT IN IRRIGATED LINSEED (*Linum usitatissimum* L.)

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ABSTRACT

A field experiment was conducted during winter seasons of 1992-93 and 1993-94 to findout effective and economical weed control measure in irrigated linseed (*Linum usitatissimum* L.). Twelve weed control treatments were tested taking linseed variety Kiran. All the treatments were found significantly effective in reducing total weed intensity as compared with control. As regards the seed yield, next to the handweeding twice, fluchloralin 1.0 kg/ha PPI + one interculture and isoproturon 1.0 kg/ha pre-and post-emergence in 1992-93, and isoproturon 1.0 kg/ha pre-and post-emergence proved significantly superior to control. On the basis of economic returns, application of isoproturon 1.0 kg/ha pre-emergence or isoguard 1.0 kg/ha at 25 DAS has been recommended.

Keywords : Economic weed control, irrigated linseed

INTRODUCTION

Among various factors, weed competition is an established reason for lower crop yields. In Tawa Command Area of Hoshangabad district (MP), the nature of weed problem has been observed to change in terms of relative dominance and intensity of different weed species and the problem has become more serious under irrigated condition (Anonymous, 1984). Due to scarcity of labour, use of herbicides appear to be an alternative for hand weeding. Therefore, the present study was undertaken to findout an effective and economically viable weed control schedule for linseed under irrigated condition, in Tawa Command Area.

MATERIALS AND METHODS

The Field experiment was conducted at Zonal Agricultural Research Station, Powarkheda, Hoshangabad (M.P), during winter seasons of 1992-93 and 1993-94. The experimental soil was deep vertisol with 7.9pH, low in available N (80 kg/ha). Medium in P (16 kg/ha) and high in K (228 kg/ha) contents.

Linseed variety Kiran was drilled in rows 30 cm apart, using 30 kg/ha seed, on 26 November, 1992 and 7 December, 1993. Fertilizer schedule comprised of 60 : 40: 20 kg N, P_2O_5 and K_2O/ha, respectively. Half of the N was applied as basal and the remaining half was top dressed with first irrigation. Crop received two irrigations i.e. at 35 and 70 DAS during both years. The experiment was laidout in RBD with 12 treatments (table-2) replicated thrice. The crop was harvested on 22 March, 1993 and 6 April, 1994 during first and second year, respectively. The economic viability of different treatments was determined by using current market rates of different inputs and out put.

RESULTS AND DISCUSSION

Effect on Weeds:

The total weed intensity, observed at harvesting stage under control plots, was 7.87 and 7.23 lakh plants/ha during 1992-93 and 1993-94, respectively (Table-1). *Cichorium intybus* L., *Chenopodium album L.*, and *Melilotus* Spp. among annuals, and *Cyperus rotundas* L. and *Cynodon dactylon* pears. among perennials were the dominant weed species of the experimental field.

The total weed intensity was significantly

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influenced by different treatments (table-2). Data revealed that during 1992-93 the total weed intensity was lowest with pendimethalin 0.75 + one IC which was at per with that under handweeding twice. During 1993-94 weed intensity was lowest under isoproturon 1.0 kg/ha (post emergence) which was at par with handweeding twice. All the treatments registered significant reduction in the total weed intensity as compared to control.

Effect on linseed :

The plant population of linseed during 1992-93 did not differ significantly, but in 1993-94 it varied significantly due to different treatments (Table.2). In the second year, plant population in pendimethalin treated plots (T3, T4, T5, T6) was reduced due to herbicidal toxicity. As the spray of pendimethalin was done on 3rd day after sowing, and about 10 hours after the spray a winter shower (9.0 mm) was received. The germinating seedlings of linseed absorbed in herbicide and got adversely affected.

At Regional Agricultural Research Station, Sagar also, lower plant stand due to toxic effect of pendimethalin was observed in a similar trail under AICORPO (Anonymous, 1993-94). Tomar *et al.* (1990) reported that the herbicides oxadiazon and metribuzin, which were selective under normal season, became phytotoxic to linseed due to winter rains. In case of isoproturon applied at 1.0 kg/ha post emergence, yellowing and drooping of crop plants was observed but later on they recovered safely with drying of a few older leaves.

The number of primary branches/plant, capsules/plant and seed yield of linseed were found to be significantly affected due to different treatments during both the years. In 1992-93 maximum number of primary branches and capsules/plant were noted under isoguard 1.0 kg/ha treated plots which showed parity with isoproturon 1.0 kg/ha postem + one IC and handweeding twice. During second year branching was maximum under isoproturon 1.0 kg/ha postem + one IC, whereas the highest number of capsules plant was recorded with handweeding twice. In respect of number of capsules, most of the treatments showed significant superiority over control excepting pendimethalin treated plots during both years. As regards the seed yield, hand-weeding twice was better. During 1992-93, the seed yield under fluchloralin 1.0 PPI + one IC and isoguard 1.0 was at par with hand weeding and significantly superior to control. The results with fluchloralin 1.0 are in conformity with that reported by Tomar *et. al.* (1990). Isoguard, being a mixture of isoproturon and 2,4-DE, appeared to be more effective against a broader spectrum of weeds. Among the treatments with individual herbicide, isoproturon 1.0 PE proved better, closely followed by fluchloralin 1.0 PPI. These results are in agreement with those reported by Sandhu *et al.* (1988). In 1993-94, next to the handweeding twice, only isoproturon 1.0 PE and 25 DAS could yield significantly higher than control. The treatments with pendimethalin yielded lower than control due to herbicidal toxicity resulting in reduced plant population and capsule bearing as discussed earlier.

Economic returns :

Data presented in Table-3 revealed that the incremental net returns in 1992-93 were maximum with isoguard 1.0 25 DAS followed by fluchloralin 1.0 PPI + one IC, handweeding twice and isoproturon 1.0PE. Isoguard proved to be more profitable than handweeding twice on account of its lower treatment cost as well as satisfactory yield. In 1993-94 handweeding twice gave highest incremental net return which was closely followed by isoproturon 1.0 PE and 25 DAS. In both the years consistently higher IBC ratio was noted with isoproturon 1.0 PE and isoguard 1.0 at 25 DAS which was fairly better than that with handweeding twice.

From the above findings, it can be inferred that in irrigated linseed isoproturon 1.0 kg/ha premergence or isoguard 1.0 kg/ha at 25 DAS can be successfully used as an economically viable treatment for control of annual weeds.

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Table-1 : Intensity of different weeds and their relative percentage under control plot at harvest.

S.No.	Weed species.	1992-93		1993-94	
		No.of Weeds ('000/ha)	Relative percentage	No.of weeds (000/ha)	Relative percentage
1.	*Cichorium intybus* L.	161.0	20.46	144.2	19.94
2.	*Chenopodium album* L.	223.0	28.35	53.5	7.40
3.	*Cyperus rotundus* L.	136.8	17.39	160.5	22.20
4.	*Cynodon dactylon pears*	71.7	9.11	173.9	24.05
5.	*Convolvulus arvensis* L.	93.5	11.89	53.5	7.40
6.	*Melilotus* spp.	97.1	12.34	65.9	9.11
7.	*Euphorbia hirta* L.	-	-	66.5	9.20
8.	Others	3.6	0.46	5.0	0.70
	Total	786.7	100	723.0	100

Table 2. Total weed intensity, linseed population, number of primary branches, and capsules in linseed under different treatments.

S.No.	Treatment*	Total weed intensity/m^2 (at Harvest)		Linseed population (000/ha)		Primary branches/plant.		Capsules/Plant	
		1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94
1.	Fluchloralin 1.0 kg/ha PPI	48.3	56.0	1603	2233	2.53	1.47	18.33	19.33
2.	Fluchloralin 1.0 kg/ha-PPI + One IC-30 DAS	52.3	47.3	1594	2122	3.00	1.07	20.60	20.00
3.	Pendimethalin 0.75 kg/ha PE	61.7	52.0	1588	1878	2.00	0.33	14.47	18.53
4.	Pendimethalin1.00 kg/ha PE	58.3	55.3	1726	1855	2.27	0.80	14.07	18.53
5.	Pendimethalin 1.25 kg/ha PE	57.0	52.0	1638	1789	2.33	0.53	16.60	17.33
6.	Pendimethalin 0.75 kg/ha PE+ one IC at 30 DAS	37.0	36.0	1618	1967	2.80	1.13	22.67	23.47
7.	Isoproturon 1.0 kg/ha PE	66.0	44.0	1704	2312	2.67	1.53	21.60	22.0
8.	Isoproturon 1.0 kg/ha 25 DAS	65.7	18.7	1637	2255	2.53	1.40	21.00	20.47
9.	Isoproturon 1.0 kg/ha 25 DAS + one IC 15 DAS	55.7	44.7	1693	2245	3.00	1.60	26.13	24.33
10.	Isoguard 1.0 kg/ha 25 DAS	52.3	53.3	1757	2267	3.13	1.07	28.07	18.60
11.	Handweeding twice at 20 & 40 DAS	41.7	28.0	1705	2378	2.73	1.53	25.93	26.60
12.	Control (weedy check)	78.7	72.3	1643	2578	2.93	0.60	14.87	14.67
	SEm ±	3.87	4.59	56.50	146.02	0.19	0.18	1.70	1.39
	CD (P=0.05)	11.37	13.46	NS	605.40	0.57	0.51	4.99	4.09

* PPI-Pre plant incorporation, PE-pre-emergence, DAS-Days after sowing, IC-Interculture.

Table - 3. Seed yield of linseed, Incremental net returns and benefit : cost ratio under different treatments.

S.No.	Treatment	Seed yield (kg/ha)		Incremental net-returns (Rs./ha)		Incremental benefit : cost ratio	
		1992 - 93	1993 - 94	1992 - 93	1993 - 94	1992 - 93	1993 - 94
1.	Fluchloralin 1.0 kg/ha PPI	1347	1167	340	2320	1.29	3.09
2.	Fluchloralin 1.0 kg/ha PPI + one IC at 30 DAS	1472	1021	1260	460	1.84	1.42
3.	Pendimethalin 0.75 kg/ha PE	1321	807	-120	-1370	0.91	-0.01
4.	Pendimethalin 1.00 kg/ha PE	1269	594	-1040	-3900	0.40	-1.21
5.	Pendimethalin 1.25 kg/ha PE	1264	596	-1490	-4280	0.31	-0.98
6.	Pendimethalin 0.75 kg/ha PE + one IC 30 DAS	1306	946	-440	-150	0.71	0.90
7.	*Isoproturon 1.0 kg/ha PE*	*1367*	*1246*	*1044*	*3724*	*2.59*	6.67
8.	Isoproturan 1.0 kg/ha 25 DAS	1200	1230	1044	3724	2.59	6.67
9.	Isoproturan 1.0 kg/ha 25 DAS + one IC 15 DAS	1194	1042	-1016	1454	-0.03	2.37
10.	Isoguard 1.0 kg/ha 25 DAS	1450	1133	1753	2473	3.25	4.18
11.	Handweed twice at 20 & 40 DAS	1500	1462	1110	4620	1.57	3.40
12.	Control (Weedy check)	1197	808	-	-	-	-
	S.Em ±	77.77	139.94	-	-	-	-
	CD (P=0.05)	228.12	410.47	-	-	-	-

PPI - Preplant incorporation, PE - Preemergence, DAS - days after sowing, IC - interculture.

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EFFECT OF DATES OF SOWING ON THE OCCURRENCE OF TIKKA LATE LEAF SPOT AND RUST ON GROUNDNUT IN SOUTHERN ZONE OF ANDHRA PRADESH

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ABSTRACT

To find out the effect of dates of sowing and the varietal reaction on the natural incidence of late leaf spot and rust in southern zone of Andhra Pradesh six promising groundnut varieties, JL-24, TPT-1, TCGS-1, TCG-273, K-134 and ICGS (E)-27 were sown in early *Kharif* (9th June), normal *Kharif* (15th July) and late *Kharif* (11th August) in 1990, 1991 and 1992 years in dryland farm of Regional Agricultural Research Station, Tirupati. Early sown crop suffered least with the diseases due to low inoculum potential whereas late sown crop suffered more because of ready availability of inoculum built in early sown crop. Among the six varieties, TPT-1 suffered most and K-134 suffered least with late leaf spot and rust. The highest yield was obtained from the normal *Kharif* sowings which was significantly more than the late sowing *Kharif.* Though the varietal reaction to diseases is different, the yield was not significantly differing. The best sowing times in the region to avoid late leaf spot and rust and to obtain maximum pod yields are early and normal *Kharif* sowing. The late *Kharif* sowing may be utilized for screening groundnut germplasm for diseases due to the existence of maximum inoculum load on the late sown crop

Key Words : Tikka late leaf spot, Rust, Disease severity, date of sowings, promising varieties.

INTRODUCTION :

Tikka late leaf spot (*Phaeoisariopsis personata* (Berk and Curt.) V. Arx and Rust (*Puccinia arachids* speg.) are considered to be very important foliar diseases causing loss of over 50% pod yield of groundnut (*Arachis hypogaea* L.) (Ghewande *et al.* 1983). Rust always appears in combination with leaf spot and hastens the senescence of leaves resulting in heavy defoliation (Harrision, 1972). Control of tikka late leaf spot (TILLS) and rust is becoming difficult as most of the cultivars are susceptible and no variety is absolutely resistant. The fungicidal control of TLLS and rust is found feasible in the developed countries but impracticable in the developing countries like India because of higher cost involved in pesticide and its application.

TLLS was found to escape in early sown crop (Sulaiman and Agashi, 1965) but such information is lacking in Southern Zone of Andhra Pradesh. Hence an attempt was made to evaluate the severity of these diseases in relation to sowing dates on six promising groundnut varieties.

MATERIALS AND METHODS:

Field experiments were conducted during 1990, 1991 and 1992 with three sowing dates viz., early (9 June), normal *Kharif* (15th July) and late *Kharif* (11th August) and six groundnut varieties, (JL-24, TPT-1, TCGS-1, TCG-273, K-134 and ICGS (E)-27). The design of experiment was split plot with three dates of sowing as main treatments and six varieties as sub treatments. There were four replications with a plot size of 4.5 x 4.0 M. The soil of the experimental site was a typical sandy loam (Vertisol). The crop was sown at a spacing of 30 x 10 cm, and fertilized with a basal dose of 20:40:50 N:P:K kg/ha and 500 kg/ha of gypsum

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applied as top dressing at flowering around 30 DAS. All other agronomical practices were carried out as per recommended package of practices. The severity of the diseases was assessed by adopting 1-9 scale (Subramanyam et.al., 1982). After harvesting, the pods were dried, yield in each plot was recorded and analysed statistically.

RESULTS AND DISCUSSION

The three years pooled analysis data on the severity of tikka LLS and rust on different varieties of groundnut sown on different dates and their yields are presented in Table 1. The crop remained free from infection of tikka LLS and rust upto 30 DAS in all the sowings in three years. Severity of both tikka LLS and rust in June 1st FN sown crop was significantly less than July 1st FN and August 1st FN sown crops. The severity of tikka LLS in normal and late *Kharif* sowings is at par with each other.

Rust appeared late in the season and its severity was negligible in early *Kharif* which was significantly less than in normal and late *Kharif* sowings

Among the varieties, TPT-1 recorded severe incidence of tikka LLS, which was significantly more than in K-134, JL-24 and TCG-273. The variety K-134 was least affected with TLLS which was significantly less than all other varieties tested.

TPT-1 recorded maximum severity of rust which was significantly more than in all other varieties except ICGS(E)-27. The severity of rust was least on K-134 followed by JL-24 which was significantly less than in ICGS(E)-27 and TPT-1.

Increased pod yield was observed in normal *Kharif* than in early and late *Kharif* sown crops. However it was not significantly more than in early *Kharif* sowing but was significantly more when compared to late *Kharif* sowing.

Although differences in severities of tikka LLS and rust were observed in six varieties, they did not differ significantly in yields.

Early sown crop suffers least with the disease due to low inoculum potential whereas late sown crop suffers more because of readily available inoculum on the early sown crop and also due to high relative humidity developed around the lower canopy of the plant because of dew fall, particularly in the last part of the crop season. The increase in disease severities recorded in the present studies are in agreement with the findings of Sulaiman and Agashe, 1965 and Gupta 1985. Although the severity of diseases recorded in early and normal *Kharif* sown crop differ significantly but their yields were at par with each other, which may be due to the involvement of other agronomical and environmental factors. The present study confirms the findings of Singh *et al.*, (1961).

Present study indicates that the best sowing times in the region to avoid LLS and rust and to obtain maximum pod yields are early *Kharif* and normal *Kharif*. As the disease is maximum in late *Kharif* sowing, it may be utilized for screening the groundnut germplasm against tikka and rust under natural conditions.

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Table 1. Effect of dates of sowing on Tikka LLS, Rust and yield.

Treatment	Mean Severity of Tikka LLS	Mean severity of Rust	Pod yield (Q/ha)
Dates of sowing			
Early *Kharif* (9th June)	2.9	1.40	9.84
Normal *Kharif* (15th July)	6.5	3.0	11.87
Late *Kharif* (11th August)	7.5	8.60	7.64
C.D. 5%	1.6	1.0	3.34
Varieties			
JL - 24	5.6	2.4	9.02
TPT - 1	6.2	3.2	9.85
TCGS - 1	5.8	2.6	10.02
TCG - 273	5.5	2.6	9.91
K - 134	4.8	2.3	11.44
ICGS (E)-27	5.7	3.1	9.58
C.D. 5%	0.57	0.49	NS

NS = Non Significant

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WEATHER BASED CONTROL OF GROUNDNUT LATE LEAF SPOT WITH FUNGICIDES AND PLANT EXTRACTS

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ABSTRACT

A weather-based spray schedule was deployed in southern zone of Andhra Pradesh to help the groundnut growers for effective control of late leaf spot. All the fungicidal sprays were found to be significantly superior to control in reducing the disease severity and increasing the pod yield. Two sprays of mancozeb (0.25%) + carbendazim (0.1%) based on the weather conditions was the best among all the treatments in reducing disease severity and increasing the pod yield with a net incremental benefit cost ratio of 6.14 and can readily be recommended to the groundnut growing farmers.

Key words : Groundnut, late leaf spot, fungicides, weather, benifit cost ratio.

INTRODUCTION

Late leaf spot (LLS), *Phaeoisariopsis personata* (Berks & Curt. V. Arx.) is one of the important diseases of groundnut (Mc Donald *et al.*, 1985). An yield loss upto 50% was reported due to this disease in groundnut every year (Ghewande *et al.*, 1983). Several reports appeared on the effective control of leaf spots with fungicides resulting in increased yield (Kolte *et al.*, 1979; Ponnaiah *et al.*, 1982; Gupta, 1985).

Weather data could be used to predict the onset of leaf spot disease (Jensen and Boyle, 1965). The time of initiation of LLS was predicted during rainy season by monitoring the presence of conidia, synchronising with a minimum rainfall of 8.8 mm per day and a relative humidity of 86% when the crop was 37 days old and above (Papa Rao *et al.*, 1994).

Attempts were made to find out a suitable fungicidal spray schedule based on the weather factors for effective management of LLS with a minimum number of sprays.

MATERIALS AND METHODS

JL-24, a highly susceptible genotype to LLS was used. The experiment was laidout in a randomised block design during the rainy seasons (*Kharif*) of 1992, 1993 and 1994 at Regional Agricultural Research Station (RARS), Tirupati. Eight treatments were replicated four times with a plot size of 5 x 4 m. The crop was sown at a spacing of 30 x 10 cm. A basal dose of 10 kg Nitrogen; 40 kg phosphorus and 50 kg of potash per hectare was applied at the time of sowing. Twenty five days after sowing, 10 kg of nitrogen and 500 kg of Gypsum per hectare were applied.

Five fungicides viz., Carbendazim 50 W.P.0.25%; Score 25 EC (Difenoconazole) 0.05%; Tilt 25 EC (Propiconazole) 0.1% and a combination of mancozeb 0.25% + Carbendazim 0.1% and 2% aqueous leaf extracts of neem (*Azadiracta indica* (A Juss) and Calotropis (*Calotropis juncea*) were used as treatments in apray schedules.

A prophylactic spray with fungicides and plant extracts was given when the spores were trapped in the spore trap and weather parameters like rainfall (8.8 mm) and relative humidity (86%) synchronised and the crop was above 30 days old. Second spray was given 20 days after the first spray when the above parameters were noticed. Control plots were sprayed with water.

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LLS observations were made on 1-9 scale (Subramanyam *et al.*, 1982) on 70 days old crop. Yield data were recorded and the benefit cost ratio was also calculated. The data were analysed statistically and was presented in Table-1.

RESULTS AND DISCUSSION

The data from table 1 indicate that all fungicides and their combinations had significantly reduced the severity of LLS and increased pod yield over control. None of the plant extracts tested have reducedthe disease severity and increased the pod yield. The combination of mancozeb + Carbendazim was found to be the best among all the treatments tried in reducing the disease severity (4.7) and increasing the pod yield (19.0 q/ha) followed by Tilt (LLS score 5.9; pod yield 17.37 q/ha); carbendazim alone (6.3 score and 16.45 q/ha), score (6.3 score and 15.87 q/ha); and chlorothalonil (6.7 and 16.25 q/ha).

Gupta (1985) reported that combined spray with mancozeb (0.25%) + Carbendazim (0.1%) effectively reduced the disease incidence with increased yield followed by Tilt. He further stated that five sprays were very effective, but the present study indicates that only two sprays were enough for effective control of LLS with high economic yields. The effect of carbendazim in the control of LLS of groundnut in the present study is in agreement with earlier reports (Singh and Nayak, 1977; Kolte *et al.*, 1979; Ghuge *et al.*, 1980). Duby and Mishra (1991) reported that chlorothalonil ranked fifith in the disease control. The concept of fore-casting system in the effective management of LLS of groundnut was suggested by Smith and Littrell, 1980 and Bailey *et al.*, 1994. In the present study based on the above system the number of sprays were reduced from five to two for effective control of LLS of groundnut.

The benefit cost ratio except for score was calculated as it is not marketed. All the spray schedules were found economic with incremental benefit cost ratio (IBCR) varied from 2.29 to 6.14. It is maximum in spray schedule consisting of 2 sprayings of Mancozeb + Carbendazim. (6.14) followed by Carbendazim alone (5.71). The net incremental benefit cost ratio was increased to a maximum of 6.14 compared to 2.85 as reported by Gupta (1985) and Shekhawat et.al., (1987) by reducing the number of sprays to two in the present study by following weather based spray schedule. The prrresent study indicated that 2 sprays of mancozeb + carbendazim are highly economical which gave higher returns and can be readily recommended to the farmers.

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Table 1. Relative efficacy of fungicides and leaf extracts on late leaf spot and pod yield.

Treatment	Severity of Late leaf spot (1-9 scale)	Pod Yield (Q/ha)	Benefit: cost ratio
Calotropis leaf extract 2%	8.4	13.98	-
Neem leaf extract 2%	7.7	13.71	-
Carbendazim 0.1%	6.3	16.45	5.71
Chlorothalonil 0.2%	6.7	16.25	2.29
Mancozeb 0.25% + Carbendazim 0.1%	4.7	19.00	6.14
Score 0.05%	6.3	15.87	-
Tilt 0.1%	5.9	17.37	4.47
Control	8.6	12.82	-
C.D at 5%	1.8	3.04	-

* Pooled analysis data for 3 years.

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INHERITANCE OF TESTA COLOUR AND RESISTANCE TO LATE LEAF SPOT AND RUST IN GROUNDNUT (*Arachis hypogaea* - L.)

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ABSTRACT

Inheritance of testa colour and resistance to late leaf sopt and rust were studied in F2 populations of five crosses of groundnut (*arachis hypogea* L.) viz. Kadiri - 1 (tan) x NCAC 17090 (light tan), Kadiri -1 (tan) x Ec 76446 (292) (Purple), Kadiri - 1 (tan) x P1 393527B (red), Kadiri - 1 (tan) x P1 2981145 (White) and Kadiri - 1 (tan) x P1 414331 (tan). The common ovule parent was highly susceptible to late leaf spot and moderately susceptible to rust. The male parent, EC 76446 (292) was least susceptible to both late leaf spot and rust. The study indicated involvement of five gene pairs in inheritance of testa colour. For late leaf spot resistance the study revealed that resistance is governed by four to five duplicate recessive genes. Two to three genes acting in duplicate complementary manner seem to be involved in rust resistance.

Key Words : Groundnut, testa colour, resistance to late leaf spot and rust, inheritance.

INTRODUCTION

Late leaf spot caused by *Phaeoisariopsis personata* and rust caused by *Puccinia arachidis* are the most destructive foliar diseases of grountnut. Sources of resistance against them have been identified in some genotypes of cultivated grountnuts. Transfer of resistance into cultivated varieties is thus the cheapest method of disease control as there wont be any need of extra inputs to the farmer. Thus it is necessary to ascertain the pattern of inheritance of resistance to these diseases for effective transfer of resistance into cultivated varieties. A preliminary attempt has been made in the prresent study to understand the mode of inheritance of these diseases along with testa colour.

MATERIALS AND METHODS

Five segregating Populations in F2 generation derived from five crosses viz. Kadiri - 1 X NCAC 17090, Kadiri - 1 X EC 76446 (292), Kadiri - 1 X PI 393527B, Kadiri - 1 X PI 298115 and Kadiri - 1 X PI 414331 grown during 1984 Kharif were subjected to genetic analysis. All the plants in a cross were scored for the late leaf spot and rust incidence using 1 - 9 scale developed by Subramanyam *et al.* (1982) under natural field conditions. Plants scored were classified as highly susceptible to late leaf spot and rust if the score was more than 5, as moderately susceptible if the score was between 4 & 5 and least susceptible if the score was less than or equal to 3. The description of the parents in the study is as follows:

Kadiri - 1: the female parent used was highly susceptible to late leafspot and moderately susceptible to rust with tan coloured testa.

NCAC 17090 :- Moderately susceptible to late leaf spot and least susceptible (resistant) to rust, light tan coloured testa.

EC 76446 (292) :- least susceptible to both the diseases, purple coloured testa.

PI 393527B :- moderately susceptible to late leafsopt & least susceptible to rust, red coloured testa.

PI 298115:- moderately susceptible to late leaf spot, least susceptible to rust, tan coloured testa.

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PI 414331 :- moderately susceptible tolate leaf spot, least susceptible to rust, tan coloured testa.

RESULTS AND DISCUSSION :

Testa Colour :

The F1 of the cross Kadiri - 1 (tan) X NCAC 17090 (light tan) has tan colour testa while F1 testa of crosses viz. Kadiri - 1 x, Ec 76446 (292) Purple), Kadiri - 1 (tan) X PI 393527B (Red) and Kadiri - 1 (tan) X PI 298115 (white) was purple, light red and red, respectively.The F2 phenotypic segregation ratio in the corsses Kadiri - 1 x NC 17090 and Kadiri - 1 X EC 76446 (292) was 3 tan: 1 light tan and 3 purple : 1 tan respectively, where as the F2 segrergation ratio was 1 red : 2light red: 1 tan in the cross Kadiri - 1 X PI 393527B and 45 red: 14 tan: 4 white in the cross Kadiri - 1 X PI 298115. The gene symbols assigned to parents and F1 and F2 segregants are given in Table 1 & 2 respectively. The parents, Kadiri - 1 and NCAC 17090 seem to differ at a single locus with gene for tan testa colour being in dominant condition in Kadiri - 1. EC 76446 (292) is proposed to possess locus for purple testa which did not interact with locus governing tan colour testa. From the segregation ratios in the crosses Kadiri - 1 X PI 393527 B and Kadiri - 1 X PI 298115, it is inferred that there are two separate loci for red testa colour. One red testa colour locus in the PI 393527 B seems to be inherited in an independent fashion with incomplete dominance, while the red testa colour locus in PI 298115 seems to be interacting with white testa colour locus. White testa colour locus, when it is in recessive condition, appears to be epistatic over red testa colour locus in PI 298115. The genotypic constitution of PI 298115 is proposed as ww tt pp r_1r_1 R_2R_2 while PI 393527 B as WW TT PP R_1R_1 r_2r_2. Thus altogether testa colour seems to be governed by five gene pairs that segregate independently. The ratios 3 purple: 1 rose (8), 1 red: 2 light red: 1 brown (1), 1 red: light red 2 1 tan (2 & 10) and 45 red : 14 flesh: 4 white (4) were reported by earlier workers. The results from the present study are in conformity with the above reports.

Late Leaf spot resistance:

The F1s were highly susceptible to late leaf spot in all the crosses showing that susceptibility is dominant over resistance in these crosses. The F2 segregation had a good fit to phenotypic ratio of 15 susceptible: 1 moderately susceptible in the cross Kadiri - 1 X PI 393527B and 63 susceptible: 1 moderately susceptible in crosses Kadiri - 1 X NCAC 17090, Kadiri - 1 X PI 298115 ;and Kadiri - 1 x PI 414331 and 63 susceptible: 1 least susceptible in the cross Kadiri - 1 X EC 76446 (292). The proposed genotypic constitutions of the parents and F2 and segregation ratios are presented in Table 1 and 2. From these results it is clear that resistance to late leaf spot is governed by duplicate recessive genes susceptibility being dominant to resistance. Five pairs of duplicate genes appear to be involved in late leaf spot resistance. The female parent, Kadiri - 1 is proposed to posses all genes in dominant condition i.e. Lr_1Lr_1 Lr_2Lr_2 Lr_3Lr_3 Lr_4Lr_4 Lr_5 Lr_5, while the male parents NCAC 17090, PI 393527B, PI298115 and PI414331 have 3 pairs of genes in recessive condition i.e Lr_1Lr_1 Lr_2Lr_2 lr_3lr_3 lr_4lr_4 lr_5lr_5 and EC 76446 (292) has four pairs of genes in recessive condition i.e. Lr_1Lr_1 lr_2lr_2 lr_3lr_3 lr_4lr_4 lr_5lr_5. Nevill (1980) also proposed that genes at three or four loci controlled the leaf spot resistance based on studies in F2 of a cross between robout 33-1 and Krapovickas - 16. Later on Nevill (1982) proposed genetic system involving five loci from his studies on five F2 populations from corsses between three resistant lines in which the susceptible parents were used as females. Resistant material is proposed to be homozygous resessive at loci 1,2,3, and 4: susceptible Robout 33-1 is homozygous recessive at loci 3,4 and 5, susceptible TMV2 has no resistant genes.

Rust resistance:

F1s were moderately susceptible to rust indicating that moderate susceptibility is dominant overlow susceptibility. The F2 had a good fit to a phenotypic ratio of 15 moderatley susceptible: 1 least susceptible in two crosses i.e Kadiri - 1 x EC 76446 (292) and Kadiri - 1 X PI 414331, while in the other three crosses F2 phenotypic segregation ratio was 54 moderately susceptible: 10 least susceptible. The genotypic cconstitution of the parents and F2 and segregation ratios are presented in Tables 1 and 2. The female parent, Kadiri - 1 is presumed to possess three pairs of genes in dominant condtion i.e $R_1R_1R_2R_2R_3R_3$, while the male parents NCAC 17090 and PI 298115 all the genes in recessive condition and the male parents EC 76446(292), P1 393527B and P1 414331 two pairs of genes in recessive condition. It is proposed that these three pairs of genes act in duplicate complementary manner i.e the presence of two genes in dominant condition only results in susceptibility while the presence of any one gene in dominant condition results in resistance (least susceptibility). Bromfield and Bailey (1972) reported digenic control of rust resistance with resistance being recessive. Knauft and Norden (1983) from their study in F2 and F3 populations reported that rust resistance was under the control of two duplicate genes.

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Table 1. F2 Segregation of testa colour in five crosses of Groundnut (*Arachis hypogaea* - L.)

S. No.	Cross	F1 behaviour	Number of Plants with purple testa	red testa	light red testa	tan testa	light tan testa	white testa	Ratio	Probability	Chi Square value
1.	Kadiri - 1 (tan) X NcAc 17090 (light tan)	Tan	-	-	-	269	103	-	3 : 1	0.30 - 0.20	1.434
2.	Kadiri - 1 (tan) X EC 76446 (292) Purple	Purple	271	-	-	96	-	-	3 : 1	0.70 - 0.50	0.063
3.	Kadiri - 1 (tan) X P1 393537 B (red)	Light Red	-	11	212	87	-	-	1 : 2 : 1	0.10 - 0.05	3.283
4.	Kadiri - 1 (tan) X P1 298115 (white)	Red	-	323	-	93	-	6	45 : 15 : 4	0.10 - 0.05	2.837
5.	Kadiri - 1 (tan) X P1 414331 (tan)	Tan	-	-	-	269	-	-	-	-	-

Table 2 : **Segregation for resistance to late leafspot and Rust in F_2 population of five crosses of Groundnut (*Arachis hypogaea.* L.)**

Particulars	Kadiri - 1 X Nc Ac 17090	Kadiri - 1 X EC 76446 (292)	Kadiri - 1 X P1 393527 B	Kadiri - 1 X P1 298115	Kadiri - 1 X P1 414331
Reaction to Late Spot					
F1 behaviour	Highly Susceptible	Highly Susceptible	Highly Susceptible	Higly Susceptible	Highly Susceptible
F2 behaviour					
No of plants with high susceptibility	310	282	269	283	237
No. of plants with moderate susceptibility	8	-	10	6	6
No. of plants with low susceptibility	-	7	-	-	-
Ratio	63 : 1	63 : 1	15 : 1	63 : 1	63 : 1
Chi-square value	1.879	1.389	3.384	0.496	1.299
Probability	0.20 - 0.10	0.30 - 0.20	0.10 - 0.05	0.50 - 0.30	0.30 - 0.20
Reaction to Rust					
F1 behaviour	Moderately Susceptible	Moderately Susceptible	Moderately Susceptible	Moderately Susceptible	Moderately Susceptible
F2 behaviour					
No. of plants with moderate susceptibility	266	274	247	227	284
No. of plants with low susceptibility	52	15	54	32	21
Ratio	54:10	15:1	54:10	54:10	15:1
Chi-ssquare value	0.128	0.554	3.654	2.750	0.210
Probability	0.80 - 0.70	0.50 - 0.30	0.10 - 0.05	0.10 - 0.05	0.70 - 0.50

Table 3: Assigned gene symbols for parents and F_2S

Character	Parent/F_2	Genotype	Phenotype
Testa Colour	Kadiri - 1	$WW\ TT\ PP\ r_1r_1\ r_2r_2$	Tan
	NcAc 17090	$WW\ tt\ pp\ r1r_1r_1\ r_2r_2$	Light tan
	EC 76446(292)	$WW\ TT\ PP\ r_1r_1\ r_2r_2$	Purple
	PI 393527B	$WW\ TT\ pp\ R_1R_1\ r_2r_2$	Red
	PI 298115	$ww\ tt\ pp\ r_1r_1\ R_2R_2$	white
	PI 414331	$WW\ TT\ pp\ r_1r_1\ r_2r_2$	Tan
	F_2	$WT - R_1 - r_2r_2\ pp$	
		$W - T - r_1r_1 - R_2 - pp$	Red
		$W - tt - r_1r_1 - R_2 - pp$	
		$ww - T - r_1r_1 - R_2 - pp$	
		$W - T - P - r_1r_1\ r_2r_2$	Purple
		$W - T - r_1r_1\ r_2r_2\ pp$	Tan
		$ww\ \ T - r_1r_1\ r_2r_2\ pp$	Light
		$ww\ tt\ r_1r_1\ R_2\ pp$	White
		$ww\ tt\ r_1r_1\ r_2r_2\ pp$	
Late leafspot			
	Kadiri - 1	$Lr_1Lr_1\ Lr_2Lr_2\ Lr_3Lr_3\ Lr_4Lr_4\ Lr_5Lr_5$	Susceptible
	NcAc 17090	$Lr_1Lr_1Lr_2Lr_2lr_3lr_3lr_4lr_4lr_5lr_5$	Moderately Susceptible
	PI 393527B		
	PI 414331		
	EC 76446(292)	$Lr_1Lr_1\ lr_2lr_2\ lr_3lr_3\ lr_4lr_4\ lr_5lr_5$	Least Susceptible
	F_2		
		$Lr_1 - Lr_2 - Lr_3 - Lr_4 - Lr_5$	Susceptible
		$Lr_1 - Lr_2 - lr_3lr_3\ lr_4lr_4\ lr_5lr_5$	Moderately Susceptible
		$Lr_1 - lr_2lr_2\ lr_3lr_3\ lr_4lr_4\ lr_5lr_5$	Least Susceptible
Rust			
	Kadiri - 1	$R_1R_1\ R_2R_2\ R_3R_3$	Moderately Susceptible
	NcAc 17090	$r_1r_1\ r_2r_2\ r_3r_3$	Least Susceptible
	EC 76446(292)	$r_1r_1\ r_2r_2\ R_3R_3$	Least Susceptible
	PI 393527B	$r_1r_1\ r_2r_2\ R_3R_3$	Least Susceptible
	PI 298115	$r_1r_1\ r_2r_2\ r_3r_3$	Least Susceptible
	PI 414331	$r_1r_1\ r_2r_2\ r_3r_3$	Least susceptible
	F_2	$R_1 - R_2 - R_3$	
		$R_1 - R_2 - R_3$	Susceptible
		$R_1 - r_2r_2\ R_3$	
		$r_1r_1 - R_2 - R_3$	
		$R_1 - r_2r_2\ r_3r_3$	
		$r_1r_1\ R_2 - r_3r_3$	Least Susceptible
		$r_1r_1\ r_2r_2\ R_3$	
		$r_1r_1\ r_2r_2\ r_3r_3$	

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EFFECT OF TEMPERATURE ON RUST AND LEAF SPOT DISEASE DEVELOPMENT IN GROUNDNUT[1]

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ABSTRACT

Studies on the development of early leaf spot (ELS), late leaf spots (LLS) and rust diseases of groundnut (Arachis hypogaea) in relation to temperature was carried out under laboratory conditions. Results showed that rust, ELS and LLS diseases initiation and development were more rapid on susceptible than on resistant genotypes. Rust and LLS resistant genotypes had increased incubation periods, decreased infection frequencies and leaf area damage, and reduced lesion diameters and sporulation indexes. Rust and leaf spot disease development was optimum at temperatures of 20-30°C. None of the three diseases established at temperatures below 10°C and above 35°C.

Key words: Groundnut, rust, leaf spots, temperature, Incubation period, infection.

INTRODUCTION

Groundnut (*Arachis hypogaea L.*) is the thirteenth most important crop plant grown for food in the tropical, sub-tropical and warm temperate zones of the world (Mangelesdrof, 1961). Groundnut production is limited by numerous plant diseases. The most prevalent of these diseases are the rust, early leaf spot (ELS) and late leaf spot(LLS) caused by *Puccinia arachidis* speg., *Cercospora arachidicola* Hori and *Phaeoisariopsis* (Berk & Curt.) V. Artx. respectively. Subrahmanyam *et al.* (1980) reported 70% yield losses in susceptible genotypes from combined attack of rust and leaf spots and losses were more in the rainy season than in the postrainy season. In this paper, the effect of various temperatures on rust and leaf spot disease development is reported.

MATERIALS AND METHODS

The effect of temperature on rust, early and late leaf spots diseases development on three groundnut genotypes viz., TMV 2, NC Ac 17129 and PI 350680 with varying degree of resistance to these diseases, whose resistance was confirmed over several seasons at International Crops Research Institute for Semi-Arid Tropics (ICRISAT) Center, Patancheru, India (Subrahmanyam *et al.*, 1983b). The experiment was conducted during the year 1984, 1985 adopting completely Randomised Block (CRBD) design. The plants were grown in plastic pots (15 cm diameter) containing a mixture of red sandy soil and farm yard manure (4:1 v/v) in a greenhouse at ICRISAT Center, Patancheru. On thirty day old plants, leaves from the middle portion of the main stem were excised through the pulvinus, washed in running tap-water, and arranged with their petioles buried in a layer of sterilised sand in plastic trays 55 cm long x 27.5 cm wide x 5cm deep (Subrahmanyam *et al.*, 1985). The sand was moistened with Hoagland's *nutrient solution (Hoagland and Arnon, 1950).* Ten leaves of each genotype were randomly arranged in each tray in upright position, and the leaf areas were determined using leaf area meter (Li-COR Inc., Model 3100, Lincoln, Nebraska). Trays were covered with clear polyethylene bags and placed in plant growth chambers (Percival

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Inoculum of *P. arachidis, C. arachidicola* and *P. personata* from a single lesion on a susceptible genotype in the field was produced on detached leaves of TMV 2 in a growth chamber. Spores were harvested with cyclone spore collector (ERI Instrument shop, Iowa State University, Ames) suspended in sterile distilled water containing Tween-80 (Polyoxyethylene sorbitan monooleate) (0.2 ml/100 ml of water) and adjusted to about 1 x 10^{-5} spores per milli liter. Trays were removed from growth chambers, and conidial suspensions were atomised on to the leaves on both surfaces until incipient run-off. Trays were again covered with polyethylene bags and placed in plant growth chambers at 25°C for 24 and 48 hr for rust and leaf spots, respectively. Then the trays were transferred to various temperatures viz., 10, 15, 20, 25, 30 and 35°C in plant growth chambers. In preliminary experiment as the temperature was 2°C more inside the tray than outside, the temperatures in the plant growth chambers were adjusted in such a way that the required temperature was maintained inside each tray. The experiment was repeated two times.

From 7 days after inoculation, the leaves were examined daily and the number of lesions appearing were recorded. When daily increase in number ceased, the following parameters were recorded.

Incubation period: The number of days between inoculation and appearance of 50% of the lesions,

Infection frequency: Final number of lesions per cm^2 of leaf area,

Percentage leaf area damaged: The leaf area damaged by rust, early and late spots were estimated by comparison with diagrams depicting leaf areas with known percentages of their areas

Lesion diameter: The diameters of ten randomly selected lesions of rust and leaf spots were measured using an ocular micrometer and millimeter scale, respectively.

Sporulation: The extent of sporulation of rust and leaf spots were scored on ten randomly selected lesions on 1-5 scale (Subrahmanyam *et al.*, 1983b) using stereomicroscope (x70),

Percentage defoliation: The percentage defoliation was calculated by counting the number of leaflets and number of abscised leaf-lets on each leaf.

RESULTS AND DISCUSSION

The incubation period was high and infection frequency, lesion diameter, percentage leaf area damaged and sporulation index were lower for resistant (PI 350680) and moderately resistant (Nc Ac 17129) genotypes than for the susceptible genotype (TMV 2) (Table 1).

The incubation period was longer at lower temperatures (15 and 20°C) than at the higher temperatures (25 and 30°C) for all genotypes. Zhou *et al.* (1980) also reported that incubation period was long at low temperature (18°C) and short at high temperature (24.5 to 26°C). Infection frequency was highest at 25°C for TMV 2 but lowest for NC AC 17129, which had highest infection frequency at 30°C. Temperatures between 15 and 30°C did not significantly effect infection frequency or lesion diameter for PI 350680. Lesions were large at 20, 25 and 30°C but small at 15°C for TMV 2 and NC Ac 17129. The percent leaf area damaged was highest at 30°C for TMV 2 and NC Ac 17129. No significant differences were observed in sporulation index in TMV 2 and NC Ac 17129 plants at temperatures in the 15-30°C range. It was lowest at 25°C for PI 350680. These results showed that there was a strong genotype x temperature interaction on rust of 20-30°C appears to be favorable for rust development on rooted detached leaves in the laboratory. Subrahmanyam and Mc Donald (1986) reported that temperature in the 20-30°C range favoured rust development in the laboratory. In the present investigation rust development was not observed at 10 and 35°C, but Mallaiah and Rao (1979) recorded slight rust development at 35°C. They also reported that the disease could be quiescent under high summer temperatures in Andhra Pradesh, but infection rapidly manifest when temperatures fell with the onset of the monsoon.

Rust resistant genotypes have increased incubation period, decreased infection frequency, leaf area damaged and reduced pustule size and spore production. These results are in agreement with those obtained by Lin (1981), Sokhi and Joohty (1982) and Subrahmanyam *et al.* (1983 a,c).

Early leaf spot disease: Early leaf spot developed on detached leaves of all test genotypes incubated at 15, 20, 25 and 30°C but not at 10 and 35°C even after 45 days of incubation. All the genotypes tested were susceptible to early leaf spot in field. Hence, there were no significant differences in incubation period, infection frequency, lesion diameter, percentage leaf area damaged and sporulation between the genotypes (Table 2).

The incubation period was longer at lower temperatures (15 and 20°C) and shorter at higher temperatures (25 and 30°C) for all the genotypes. The infection frequency was highest at 15°C and lowest at 30°C for all genotypes. NO significant effects of temperature and genotype on lesion diameter was observed. Percentage leaf area damaged was largest at 25°C for all genotypes, but low at 15, 20, and 30°C. There was no consistent trend in genotype and temperature effect on defoliation. The results on defoliation were erratic. The sporulation index was low at genotypes.

Genotype NC Ac 17129 had longest incubation period, the smallest lesions, the least percentage leaf area damage, and the lowest sporulation index. Although the three genotypes used in this investigation were all susceptible to early leaf spot pathogen in field screening, the genotypes NC Ac 17129 and PI 350680 had smaller lesions and lower sporulation index than TMv 2. This indicates that if these genotypes are grown in large areas, they might show a reduced apparent infection rate (r) because of low spore production. However, field trials are required to verify this hypothesis.

Late leaf spot disease: In general, the resistant (PI 350680) and moderately resistant (NC Ac 17129) genotypes had higher incubation period, reduced infection frequency, lesion diameter, percentage leaf area damaged, percentage defoliation and sporulation than the susceptible TMV 2 (Table 3). The incubation period was larger at 15 and 20°C and shorter at 25 and 30°C for all genotypes. Infection frequencies were high at 15, 20 and 25°C and low at 30°C for all genotypes. There was no difference in the lesion diameter between 15, 25 and 30oC. The percentage leaf area damaged was highest at 25°C followed by 15, 30 and 20°C. The percentage defoliation was more at 25°C followed by 30, 20 and 15°C for all genotypes. The results on defoliation were erratic. Within the range of 15-30°C there were no significant effects of temperature on sporulation index.

Our results indicate that leaf spot - resistant genotypes have increased incubation period, and decreased infection frequency, leaf area damage, and defoliation, and reduced lesion size and spore production and are in agreement with the previous workers results (Nevill, 1982; Subrahmanyam *et al.*, 1982; Zhou *et al.*, 1981;).

The results in the present investigation indicate that there was a strong genotype x temperature interaction on foliar disease development. In general, temperatures in the 20-30°C range favour rust, early and late leaf spot development on detached leaves in the laboratory. However, further trials are required to determine the optimum temperature requirements for each of these diseases. Rust and late leaf spot resistant genotypes have an increased incubation period, decreased infection frequency, leaf area damage, and reduced lesions and spore production. This type of reaction to diseases was similar to the "partial resistance" reported by various workers in several host-pathogen interaction studies (Hooker, 1967; Parieveliet, 1975; Mac Kenzie, 1976; Berger, 1977; Shaner and Finney, 1980).

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Table 1. Effect of temperature on rust disease development on three groundnut genotypes under monocyclic infection in the laboratory (Pooled analysis)

Genotype	Temperature (°C)	Parameters				
		Incubation period (days)	Infection frequency (lesions/cm^2)	Lesion diameter (mm)	Leaf area damaged (%)	Sporulation index
TMV 2	15	32.9	3.4	0.52	2.80 (9.61)	4.80
	20	18.1	3.2	0.60	3.50 (10.78)	5.00
	25	10.2	3.6	0.63	3.30 (10.51)	4.85
	30	10.3	3.45	0.61	6.70 (14.97)	4.90
	CD 5%	0.871	0.811	NS	1.27	NS
NC Ac 171129	15	35.9	2.65	0.43	2.70 (9.58)	4.40
	20	21.0	2.65	0.46	3.00 (10.00)	4.30
	25	12.6	1.75	0.46	2.90 (9.86)	4.10
	30	12.8	2.55	0.48	3.90 (11.37)	4.00
	CD 5%	1.91	NS	NS	0.82	NS
PI 350680	15	38.1	1.30	0.38	1.30 (6.32)	3.35
	20	23.6	1.35	0.40	0.90 (5.36)	3.25
	25	15.1	1.00	0.39	1.70 (7.48)	1.75
	30	14.3	0.85	0.39	1.20 (6.42)	2.20
	CD 5%	1.97	NS	NS	NS	0.77

Angular values in the parentheses

Table 2. Effect of temperature on the early leaf sopt development on three groundnut genotypes under monocyclic infection in the laboratory (Pooled analysis)

Genotype	Temperature (°C)	Parameters					
		Incuba-tion period (days)	Infection frequency (lesions/cm2)	Lesion diameter (mm)	Leaf area damaged (%)	Defoliation (%)	Sporula tion index
TMV 2	15	22.80	2.4	3.55	7.90 (16.41)	16.00 (23.63)	3.80
	20	20.51	2.1	3.70	11.50 (19.86)	14.90 (22.72)	4.50
	25	13.9	2.3	3.40	18.20 (25.25)	21.20 (27.44)	4.45
	30	13.9	1.9	3.40	7.80 (16.21)	12.50 (20.70)	4.40
	CD 5%	1.45	NS	NS	NS	NS	NS
NC Ac 17129	15	25.3	2.8	2.60	8.60 (17.00)	8.70 (17.16)	3.40
	20	22.1	2.3	3.15	10.90 (19.32)	13.70 (21.75)	4.10
	25	14.8	2.2	2.70	12.90 (21.05)	14.90 (22.72)	4.00
	30	14.9	1.9	2.55	6.10 (14.32)	12.50 (20.70)	3.85
	CD 5%	4.71	NS	NS	NS	NS	0.27
PI 350680	15	24.1	2.1	2.80	6.10 (15.53)	13.70 (21.75)	3.35
	20	20.6	1.8	3.10	6.20 (14.43)	18.60 (25.56)	3.50
	25	14.2	1.6	2.75	13.30 (21.42)	12.50 (20.70)	4.00
	30	13.8	1.2	2.70	10.80 (19.26)	11.20 (19.57)	3.90
	CD 5%	2.89	NS	NS	NS	NS	NS

Angular values in the parentheses.

Table 3. Effect of temperature on the late leaf spot development on three groundnut genotypes under monocyclic infection in the laboratory (pooled analysis)

Genotype	Temperature (°C)	Parameters					
		Incuba-tion period (days)	Infection frequency (lesions/cm2)	Lesion diameter (mm)	Leaf area damaged (%)	Defoliation (%)	Sporula tion index
TMV 2	15	24.4	3.6	2.4	14.50 (22.43)	12.40 (20.62)	4.65
	20	17.8	2.9	3.0	14.30 (22.22)	13.70 (21.75)	4.95
	25	12.6	3.7	2.4	17.50 (24.73)	23.70 (29.16)	4.80
	30	11.8	2.7	2.8	11.20 (19.58)	13.70 (21.71)	4.35
	CD 5%	NS	NS	NS	NS	NS	NS
NC Ac 17129	15	25.6	2.2	2.1	8.30 (16.76)	12.40 (20.62)	3.85
	20	21.6	3.0	2.1	7.70 (16.14)	9.80 (18.30)	3.60
	25	14.7	2.2	1.9	10.10 (18.56)	15.00 (22.79)	3.65
	30	13.85	1.6	1.6	9.00 (17.52)	15.00 (22.79)	3.65
	CD 5%	0.95	NS	NS	NS	NS	NS
PI 350680	15	30.7	2.3	1.1	5.50 (13.62)	7.50 (15.89)	2.75
	20	23.8	2.6	1.1	6.40 (14.69)	10.90 (19.36)	2.85
	25	16.8	2.6	1.1	7.00 (15.39)	10.00 (18.44)	2.90
	30	16.3	1.4	0.9	5.40 (13.49)	8.40 (16.89)	2.35
	CD 5%	1.59	NS	NS	NS	NS	NS

Angular values in the parentheses.

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EFFECT OF TEMPERATURE ON *IN VITRO* VIABILITY OF RUST AND LEAF SPOT PATHOGENS OF GROUNDNUT*

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ABSTRACT

Groundnut rust (*Puccinia arachidis*) urediniospores and late leaf spot (*Phaeoisariopsis personata*) conidia were collected and stored at - 17, 10, 20, 30 and 40°C. Viabilities of spores were determined at 10 - day intervals for 20 days. Viability and infectivity of these pathogens were also tested after storing them at - 17, 10, 20 and 30°C at 10, 20, 40, 80 and 160 days storage.

Groundnut rust urediniospores were viable for about 200 days when stored at - 17 and 10°C. At 20°C and 40°C spores were viable for 30 days and 10 days respectively. At 30°C, there was no viability even at 10 days of storage. At 10 and - 17°C there was viability and infectivity at all times of testing. At 20°C, the viability lost after 20 days of storage, infectivity was shown at all times of testing. Almost similar trend was observed at 30°C. No germination of urediniospores at - 17°C and low percentage of germination at 5, 10, 15 and 35°C after both 12 and 24 hr of incubation. Temperatures in the range of 20-300C were favorable for germination, the optimum being 25°C.

Conidia of late leaf spot pathogen remained viable for over 200 days when stored at -17, 10 and 20°C. At 30°C, the viability was lost after 10 days of storage; whereas at 40°C it was for 40 days. In infectivity tests the spores preserved at - 17 and 10°C had given infection even after 160 days of storage. Though there was no germination of spores after 40 days of storage at 20°C, about 50% infectivity was recorded. No germination but the infectivity was observed at 30°C at 20 days after storage. The percentage germination was high at temperatures between 15 to 30°C. No conidia germinated at - 17°C. Very low germination was observed at 5, 10 and 35°C. The percentage germination was significantly higher after 24 hr. than after 12 hr. of incubation. Both early and late leaf spot pathogens survived at 45°C for over 120 days in the infected leaves as vegetative mycelium or stroma.

Key Words : *Groundnut; rust; leaf spots; sporulation; temperature; spore germination; viability; infectivity.*

INTRODUCTION

Early leaf spot (*Cercospora arachidicola* Hori), late leaf spot (*Phaeoisariopsis personata* (Berk. & Curt.) V.Arx) and rust (*Puccinia arachidis* Speg.) are the most serious foliar diseases of groundnut (*Arachis hypogaea* L.) on a world scale (Jackson and Bell, 1969; Gibbons, 1980; Porter *et al.*, 1982; Subrahmanyam and McDonald, 1983). In the less developed countries of semi-arid tropics where farmers do not apply fungicides for the control of the diseases, losses in yield of pods commonly exceed 50% (Gibbons, 1980). Very little information is available on the epidemiology of these diseases, especially on the effect of temperatures on the viability of these pathogens (Mallaiah and Rao, 1979b, Mau Blanc, 1925; Ramakrishna and Appa Rao 1968; Roldan and Querijero, 1939).

This paper describes an investigation into the effects of temperature on rust and late leaf spot spore viability, infectivity, spore germination and survival of leaf spots pathogens in the infected leaves.

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MATERIALS AND METHODS

Effect of temperature on rust and late leaf spot spore viability

To obtain inoculum of *P.arachidis*, *C. arachidicola* and *P. personata*, a single lesion from a susceptible genotype in the field was reinoculated on detached leaves of TMV 2 in the growth chambers. The inoculation further multiplied on TMV 2 in the greenhouse.

The leaves infected with rust and late leaf spot were collected, washed in running tap water and incubated for 72 hr in plastic trays (55 cm long, 27.5 cm wide, 5 cm deep) lined with moist filter paper. The trays were covered with polyethylene bags. Spores were then harvested with cyclone spore collector (ERI Instrument Shop, Iowa State University, Ames) and suspended in sterile distilled water and their percentage viability was estimated by standard germination tests before storage.

Approximately, 2 mg of spores were placed in glass vials (2.5 cm long x 0.5 cm diameter). The vials were fitted with cork stoppers and sealed with paraffin wax. The vials were stored in the dark at temperatures of -17, 10, 20, 30 and 40°C. Sixty vials containing spores were placed in each temperature.

At 10-day intervals, three vials were taken at random for each temperature. The spores in each vial were suspended in a few milliliters of distilled water containing traces of Tween-80 (Polyoxyethylene sorbitan monooleate) and the vials were shaken well for 1-2 min on Vortex-Genie mixer (Model K-550-GE, Scientific Industries INc., New York). One or two drops of this suspension were added to a glass slide which was then placed in a petri plate lined with moist filter paper. Two slides were kept in each petri plate. Subsequently, the plates were incubated in the laboratory (in the dark for rust and in the light for late leaf spot) for 15 hr. A drop of 0.1% mercuric chloride solution was then added to each slide to arrest further germination (Melouk and Banks, 1978; Subrahmanyam *et al.*, 1983) and slides were observed under microscope for spore germination. A total of 200 spores were counted for each replication (vial)and percentage germination was estimated.

Viability and infectivity of spores stored at different temperatures

Spores of rust and late leaf spot pathogens were collected as described above and distributed into screw capped glass vials (5 mg per vial). The vials were stored at temperatures of -17, 10, 20 and 30°C as described earlier. Three replications were maintained, each replication consisting of 5 vials. The spores were tested for germinability and infectivity at 10, 20, 40, 80 and 160 days after storage. One vial was taken from each replication and spores were suspended in sterile distilled water. The spore concentration was adjusted to 50,000 spores ml^{-1} using a hemacytometer. One or two drops of suspension from each replication was placed on a glass slide and germinability was determined as described earlier.

For infectivity, mature, undamaged, apparently healthy leaves of green-house grown groundnut plants (TMV 2) were excised through the pulvinus base from the middle portions of the main stem, washed in distilled water and the leaves surfaces were blotted using a tissue paper. Five detached leaves were used in each replication. A total of 15 leaves were inoculated with spore suspension with stomiser on both surfaces of the leaves until incipient run-off and arranged in plastic trays with their petioles buried in a layer of sterilised sand. The sand moistened with Hoagland's nutrient solution (Hoagland and Arnon, 1950). Trays were covered with clear polyethylene bags and placed in plant growth chambers (Percival Refrigeration & Mfd.Co., Boone, IA) at 25°C with 12 hr photoperiod. Untreated leaves served as controls. The leaves were observed for disease development after ten days. The percentage of leaves infected was determined.

Survival of leaf spots pathogens in infected leaves at 45°C

Leaves of the genotype TMV 2 infected with early and late leaf spots were collected separately from the greenhouse and all the conidia were washed from the lesion surfaces using cyclone spore collector as described earlier. The leaves were then surface disinfected with 0.1% mercuric chloride solution, then washed in several changes in sterile distilled water and oven dried at 30°C for 6 hr. Leaves were placed in cardboard boxes (20 x 8 cm) with a layer of sterilised sand at the bottom and incubated in the dark at 45°C. Leaves treated similarly but incubated at laboratory temperature (25-30°C) served as controls. There were two replications for each treatment.

At 30-day intervals, two leaves were removed from each replication and incubated in Petri plates filled with moist sand for 24 hr. Later, infected portions of leaves were scraped off with a sterile blade and placed on glass slides and incubated in Petri plates lined with moist filter paper for about 10 days and then examined for sporulation. This experiment was conducted for four months.

Rust and late leaf spot spore germination

Spore suspensions (50,000 spores ml^{-1}) of rust and late leaf spot pathogens were prepared as described earlier. One or two drops of the suspension were placed on glass slides and incubated in petri plates lined with moist filter paper. The petri plates were incubated in the dark for rust and in the light for late leaf spot at -17, 5, 10, 15, 20, 25, 30 and 35°C. Percentage germination was determined at 12 and 24 hours after incubation. There was one slide per Petri plate and three replications were maintained for each treatment.

RESULTS AND DISCUSSION

Rust

The initial viability of rust urediniospores before storage was 87.4%. At -17°C and 10°C the urediniospores remained viable for over 200 days of storage. At 20°C, there was 47.3% germination at 10 days after storage, the viability decreased rapidly with increase in storage time (30 days). At 30°C there was no viability even at 10 days of storage. At 40°C the percentage viability at 10 days of storage was 7.6. However, in subsequent samplings there was no viability at 40°C. At 20, 30 and 40°C, although there was no viability for some period of storage, very low percentage (0.2 to 0.3) of spores showed viability at various periods of storage (Table 1).

The infectivity was 100% even the percentage germination was 1.7 at 10 days of storage at 30°C. Though there was no germination after 10 days of storage at 30°C, the infectivity was shown at 40 and 160 days of storage. At 20°C, the viability lost after 20 days of storage, but a few spores germinated after 40 days of storage. However, though there was no germination, infectivity was shown at all times of testing (Table 2). At 10 and -17°C there was viability and infectivity at all times of testing. It is interesting to note that although the spores did not germinate on glass slides, they caused infection on groundnut leaves at 30 and 20°C. The results from *in vitro* germinability tests were in accordance with those of Subrahmanyam and Mc Donald (1982) who did not carry out infectivity tests. Zhou (Personal communication to D.McDonald) in the people's Republic of China also obtained similar data on the effects of storage temperature on spore germinability. He also examined samples for ability to infect groundnut leaves and as in the present study, found that infectivity could be demonstrated when no germination could be shown in the *in vitro* slide germination test.

Germination of urediniospores on host leaf surfaces may be stimulated by chemical factors released by the leaves. However, this was not investigated in the present study.

Regarding the effect of temperature on the spore germination, there were significant differences in percentage germination at different temperatures (Table 3). There was no germination at -17°C and only very low percentage of spores germinated at 5, 10, 15 and 35°C after both 12 and 24 hr incubation. Temperatures in the range of 20-30°C were favorable for urediniospores germination, the optimum being 25°C. No significant differences in percentage germination were observed between 12 and 24 hr of incubation. These results are in agreement with the earlier workers findings (fang, 1977; Kono, 1977; Mallaiah and Rao, 1979a; Subrahmanyam *et al.*, 1984; Zhou *et al.*, 1980). However, Foudin and Macko (1974) reported that the optimum temperature for urediniospores germination was around 18°C.

Leaf spots

The initial viability of conidia of late leaf spot pathogen before storage was 91.8%. At -17, 10 and 20°C, the conidia remained viable for over 200 days of storage (Table 4). However, at 20°C, the viability was very low. At 30°C, the viability was only 6% after 10 days of storage. At 40°C, there was a depletion in viability with increase in period of storage (40 days).

In the infectivity tests, though, the spores were viable for 160 days at -17°C, the percentage viability at each sampling time was lesser at -17°C than at 10°C. However, the percentage of leaves infected with spores at above temperatures were more or less similar (Table 5). Some spores were viable after 160 days at 20°C, however, the percentage viability decreased with increase in period of storage. Although, there was no germination of spores on glass slides after 40 days of storage at 20°C, about 47% of leaves inoculated with the same batch of spores developed late leaf spot lesions. There was an opposite trend at 160 days storage. Although, the percentage spore germination as measured on glass slide was zero at 20 days of storage at 30°C, over 40% of leaves inoculated with the spores developed disease.

In general, lower temperatures (-17°C and 10°C) prolonged the viability and infectivity of the conidia. The short duration of survival of conidia at 30°C was probably because of invasion of conidia by hyperparasite, *Verticillium lacani*. No such invasion of conidia by hyperparasite was observed at other storage temperatures.

The percentage germination was high at temperatures in the range of 15 to 30°C. No conidia germinated at -17°C, and only very low percentages of conidia germinated at 5, 10 and 35°C. The percentage germination was significantly higher after 24 hr than after 12 hr of incubation (Table 6). The germination of rust urediniospores and late leaf spot conidia were similarly influenced by temperature, this was to be expected as the two diseases commonly occur together in India and in other groundnut growing countries.

The results on survival of early and late leaf spots pathogens in infected leaves as vegetative mycelium or stroma incubated at 45°C and at the laboratory temperature showed that at each sampling time when the infected leaves were incubated at high humidity fresh conidia were produced almost all lesions. Early and late leaf spots pathogens can survive in infected leaves for over 120 days, even at 45°C. Roldan and Querijero (1939) reported that leaf spot pathogens persist in soil from one season to next as stroma in the debris and the stroma could produce fresh conidia as conditions became more favourable. The present results also indicated that the pathogen persisted as mycelium or stroma at higher temperature, was able to produce new conidia under favourable conditions.

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Table 1. Effect of temperature on viability of urediniospores of *Puccinia arachidis*.

Days after storage	Percentage germination at different temperatures (°C)1 40	30	20	10	-17
10	7.6 (14.2)	0.0 (0.0)	47.3 (43.5)	31.2 (33.7)	16.5 (20.6)
20	0.0 (0.0)	0.0 (0.0)	22.3 (28.0)	61.3 (52.1)	14.8 (20.9)
30	0.0 (0.0)	0.0 (0.0)	1.3 (5.2)	48.5 (44.1)	29.2 (32.5)
40	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	42.3 (38.6)	54.0 (47.3)
50	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	15.0 (20.2)	17.2 (19.7)
60	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	29.5 (32.4)	23.3 (24.2)
70	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	7.3 (14.2)	1.3 (5.0)
80	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	57.2 (49.2)	18.9 (24.5)
90	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	41.5 (40.1)	26.3 (30.5)
100	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	40.5 (39.5)	25.5 (28.4)
110	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	28.2 (31.3)	4.3 (9.6)
120	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	46.2 (42.8)	17.0 (23.0)
130	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	37.0 (37.3)	5.2 (12.6)
140	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	23.3 (28.2)	5.5 (12.8)
150	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	31.8 (34.3)	16.0 (23.4)
160	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	32.8 (34.9)	21.7 (25.5)
170	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	13.0 (17.5)	7.2 (15.3)
180	0.2 (1.4)	0.0 (0.0)	0.0 (0.0)	21.0 (27.1)	13.7 (21.0)
190	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	21.2 (27.3)	5.8 (13.9)
200	0.3 (1.9)	0.0 (0.0)	0.0 (0.0)	23.7 (29.1)	20.0 (24.9)
SE±	4.84				
CV (%)	78.1				

1 - Average of three replications
- Angular transformation values are presented in parenthesis.

Table 2. Effect of temperature on viability and infectivity of urediniospores of *Puccinia arachidis*.

Days after storage	30		20		10		-17	
	Per cent germination	Per cent leaves infected	Per cent germination	Per cent leaves infected	Per cent germination	Per cent leaves infected	Per cent germination	Per cent leaves infected
10	1.7 (7.3)	100.0 (90.0)	41.7 (40.0)	93.3 (81.1)	51.7	100.0 (90.0)	9.7 (17.9)	100.0 (90.0)
20	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	93.3 (81.1)	68.0	40.0 (38.9)	2.2 (6.9)	46.7 (43.1)
40	0.0 (0.0)	13.3 (17.7)	4.5 (11.6)	100.0 (90.0)	81.3	100.0 (90.0)	54.2 (47.4)	100.0 (90.0)
80	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	13.3 (17.7)	68.5	100.0 (90.0)	2.8 (9.5)	33.3 (35.0)
160	0.0 (0.0)	13.3 (17.7)	0.0 (0.0)	6.7 (8.9)	58.8	100.0 (90.0)	2.3 (8.7)	33.3 (35.0)
SE±	3.0	5.16						
CV (%)	23.4	15.2						

Percentage germination and infection of urediniospores stored at different temperatures (°C)[1]

1 - Average of three replications
- Angular transformation values are presented in parenthesis

Table 3. Effect of temperature on germination of urediniospores of *Puccinia arachidis*.

Incubation time (hours)	35	30	25	20	15	10	5	-17
12	0.6 (4.2)	87.0 (68.9)	94.6 (76.6)	93.3 (75.2)	12.6 (20.8)	2.2 (8.5)	2.5 (9.1)	0.0 (0.0)
24	1.2 (6.4)	88.4 (70.2)	94.0 (76.3)	91.5 (73.6)	14.2 (22.0)	8.8 (17.0)	5.5 (13.5)	0.0 (0.0)
SE ±	1.41							
CV (%)	5.8							

Percentage of germination of urediniospores at different temperatures (°C)[1]

1. Average of three replications
Angular transformation values are presented in parenthesis.

Table 4. Effect of temperature on viability of conidia of *Phaeosariopsis personata*

Days after storage	Percentage germination at different temperatures (°C)[1]				
	40	30	20	10	-17
10	49.7 (49.8)	6.0 (13.4)	24.7 (27.3)	2.2 (8.3)	1.2 (5.0)
20	15.0 (22.4)	0.0 (0.0)	25.5 (30.3)	85.8 (69.4)	19.8 (24.5)
30	1.8 (5.7)	0.0 (0.0)	7.8 (16.2)	69.0 (56.4)	43.2 (40.8)
40	1.0 (4.6)	0.0 (0.0)	0.0 (0.0)	86.8 (69.0)	3.8 (10.4)
50	0.0 (0.0)	0.0 (0.0)	2.0 (7.5)	26.5 (27.8)	25.3 (24.7)
60	0.0 (0.0)	0.8 (4.3)	0.0 (0.0)	12.3 (15.7)	27.7 (28.4)
70	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	40.5 (39.5)	13.3 (19.1)
80	0.2 (1.4)	0.0 (0.0)	1.7 (7.4)	62.8 (52.5)	55.2 (48.5)
90	0.0 (0.0)	0.0 (0.0)	3.5 (10.3)	62.0 (52.0)	46.2 (42.8)
100	0.0 (0.0)	0.0 (0.0)	0.3 (1.9)	47.2 (43.3)	37.7 (36.9)
110	0.0 (0.0)	0.0 (0.0)	1.0 (4.7)	42.7 (40.7)	16.8 (24.0)
120	0.0 (0.0)	0.0 (0.0)	1.0 (4.7)	38.8 (38.5)	27.0 (31.3)
130	0.0 (0.0)	0.0 (0.0)	1.2 (6.2)	52.5 (46.5)	24.2 (29.4)
140	0.0 (0.0)	0.0 (0.0)	1.2 (6.2)	50.5 (49.3)	38.3 (38.1)
150	0.0 (0.0)	0.0 (0.0)	1.3 (6.6)	32.8 (34.9)	27.7 (31.7)
160	0.0 (0.0)	0.0 (0.0)	0.3 (1.9)	32.8 (34.9)	16.2 (23.4)
170	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	38.0 (37.9)	33.0 (35.0)
180	0.0 (0.0)	0.0 (0.0)	0.2 (1.4)	47.2 (43.4)	24.3 (29.5)
190	0.0 (0.0)	0.0 (0.0)	0.3 (1.9)	46.2 (42.8)	27.8 (31.8)
200	0.0 (0.0)	0.0 (0.0)	0.5 (3.3)	49.5 (44.7)	28.7 (32.1)
SE ±	5.2				
CV (%)	56.2				

1 - Average of three replications
- Angular transformation values are presented in parenthesis.

Table 5. Effect of temperature on viability and infectivity of conidia of Phaeoisariopsis personata

Days after storage	Percentage germination and infection of urediniospores stored at different temperatures (°C)[1]							
	30		20		10		-17	
	Per cent germination	Per cent leaves infected	Per cent germination	Per cent leaves infected	Per cent germination	Per cent leaves infected	Per cent germination	Per cent leaves infected
10	6.0 (13.4)	93.3 (81.1)	32.2 (34.4)	93.3 (81.1)	3.2 (10.2)	100.0 (90.0)	3.2 (10.2)	100.0 (90.0)
20	0.0 (0.0)	53.3 (46.9)	30.8 (33.7)	60.0 (56.2)	75.8 (60.7)	80.0 (73.1)	19.8 (26.1)	100.0 (90.0)
40	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	46.7 (38.9)	86.8 (69.0)	100.0 (90.0)	3.8 (10.4)	100.0 (90.0)
80	0.0 (0.0)	0.0 (0.0)	3.3 (10.4)	46.7 (38.9)	56.2 (48.6)	100.0 (90.0)	38.7 (38.4)	100.0 (90.0)
160	0.0 (0.0)	0.0 (0.0)	0.3 (1.9)	0.0 (1.9)	22.7 (28.3)	93.3 (81.1)	12.8 (20.8)	93.3 (81.1)
SE ±	2.08	8.56						
CV (%)	17.4	21.9						

1 - Average of three replications
- angular transformation values are presented in parenthesis

Table 6. Effect of temperature on germination of conidia of *Phaeoisariopsis personate.*

Incubation time (hours)	Percentage of germination urediniospores at different temperatures (°C)[1]							
	35	30	25	20	15	10	5	-17
12	3.9 (11.4)	87.9 (69.7)	87.7 (69.17)	85.6 (67.9)	83.1 (66.0)	11.7 (19.9)	2.4 (8.7)	0.0 (0.0)
24	4.3 (11.9)	90.2 (70.3)	92.7 (74.6)	93.6 (75.5)	86.6 (68.8)	13.4 (21.3)	3.8 (11.0)	0.0 (0.0)
SE ±	2.29							
CV (%)	7.4							

1 - Average of three replications
- Angular transformation values are presented in parenthesis

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MANAGEMENT OF POD BORER IN GROUNDNUT THROUGH MANIPULATION OF CULTURAL PRACTICES IN ALFISOLS

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ABSTRACT

With a view to reduce the cost involved in the use of insecticides in the control of pod borers of groundnut, various cultural practices were assessed for their influence on the reduction of pod borer damage for four seasons under red lateritic soil conditions. Soil application of neem cake @ 250 kg/ha at the time of sowing was superior with low pod damage (4.95%), which was 23.75 per cent less than control (8.85%). Maintaining weed free till 70 DAS (5.46%) and irrigation once in 5 days (6.08%) were the other effective cultural measures in controlling the pod borers. These measures also recorded 19.0 to 22.0 per cent increased yield over control (906 kg.ha). The plots unweeded till maturity registered 4.65 per cent increase in damage and 41.27 per cent reduction in yield over control.

Key words: Groundnut; pod borers; management; cultural practices.

INTRODUCTION

Though more than 50 species of insect and non-insect pests attack groundnut, very few such as leaf miner, white grub, tobacco caterpillar, jassids, termites and pod borers cause significant damage that results in yield reduction. In general, insects cause 10 to 20 per cent crop loss in groundnut (Wightman and Ranga Rao, 1993). However, pod borers are considered to be economically serious in some pockets of India, as they cause direct yield loss by infesting pods. The earwig, *Euborellia stali* (Cherian and Basheer, 1940), false wireworm, *Penthicoides seriatoporus* Fair (Kapadia, 1994) and termite, *Odentotermes obesus* (Kaushal and Deshpande, 1967) were reported as major pod borers in India, inflicting 20, 25 and 46 per cent pod damage, respectively. In groundnut growing tracts of Pudukkottai district of Tamil Nadu, the authors have noted regular occurrence of earwig and wireworm (sp. unidentified) and sporadic occurrence of blind ant, *Dorylus* sp. under red lateritic soil conditions. These pod borers caused 6 to 15 per cent of pod damage. Control of pod borers depends much on the use of insecticides (Barwal and Gupta, 1991) which involves high cost. In order to reduce the cost on insecticides, the present study was made to find out the efficacy of different cultural practices in reducing the incidence of pod borers of groundnut.

MATERIALS AND METHODS

Trials were conducted in red lateritic soils of National Pulses Research Centre, Vamban, Pudukkottai district of Tamil Nadu under irrigated conditions using the groundnut variety TMV 7 consecutively for four seasons (kharif 94, winter 94-95, kharif 95 and winter 95-96). There were three replications in randomised block design with a plot size of 5x4m. Soil application of FYM or composted coir pith @ 12.5 t/ha (to tide over the surface crusting and as a source of nutrient), adoption of 30 x 10 cm spacing, scheduled irrigation, application of pre-emergence herbicide Fluchloralin @ 2.0 lit/ha and one hand weeding on 35DAS and soil application of *rhizobium* @ 2 kg/ha are the common package of practices

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adopted in groundnut cultivation in Tamil Nadu (Anon., 1994). The treatment adopted with these practices was considered as control. The cultural practices namely presowing soil application of neem cake @ 250 kg/ha, biodigested slurry (BDS), press mud @ 5 tons/ha and *rhizobium* @ 5 kg/ha, irrigation once in 5 days, irrigation once in 10 days starting from 4-5 DAS (life irrigation), spacing of 30x20cm, complete weed free till 70 DAS and unweeded till maturity were assessed for their influence in reducing the pod damage due to pod borers and compared with control.

The pod damage due to pod borer complex in total was assessed at the time of harvest on the basis of per cent infested pods. The dry pod yield was recorded after harvesting and drying of the pods. Four seasons data on the pod damage and pod yield were statistically analysed. The cost: benefit ratio was worked out based on the local cost of cultivation and market values.

RESULTS AND DISCUSSION

Earwig and wireworms were the pod borers regularly occurred during all the four seasons studied. In addition to these, pod damage due to the blind ant, *Dorylus* sp was also observed during winter 94-95. The blind ants scraped the shell and bored either spherical or round (3 to 5 mm in dia) holes mostly at the beak site and fed on kernels. The infested pods were either empty or filled with sand. The symptoms of damage due to earwig and wireworms were similar as reported by Purushothaman *et al.*(1970) and Wightman and Ranga Rao (1993), respectively.

Among the various cultural practices assessed, pre-sowing soil application of neem cake @ 250 kg/ha was found to be effective and recorded significantly low pod damage in all the seasons (3.91 to 6.55 per cent). The other effective measures were irrigation once in 5 days (during kharif 94) and complete weed free till 70 DAS (during winter 94-95, kharif 95 and winter 95-96). An increase in pod damage by 2 to 10 per cent over control was recorded in plots unweeded till maturity. The other cultural measures namely application of biodigested slurry, pressmud and *rhizobium* and spacing of 30 x 20 cm did not influence the pod borer attack, as they recorded pod damage equal to that of control or slightly higher than control (Table 1).

The mean data showed significantly low pod damage in plots applied with neem cake (4.95%) followed by plots maintained completely weed free till 70 DAS (5.46%) and irrigated once in 5 days (6.08%) which were 23.75, 19.87 and 15.54 per cent less than control (8.85%). The effectiveness of neem cake might be due to insecticidal and repellent properties which reduced the pod borer attack. Ranga Rao *et al.* (1991) reported that neem cake reduced the proportion of pods scarified by termites and increased the yield significantly in groundnut. Frequent irrigations retained the moisture throughout the crop period and thus made the soil climate unfavourable for pod borers which might have resulted in low pod damage. Similarly puddling and keeping the field under this condition for a week was suggested to kill the white grubs in groundnut (Veeresh, 1974), as the pest does not thrive in that condition. Plots unweeded till maturity registered 4.65 per cent increased pod damage over control, which indicated that presence of weeds in the groundnut field would have favoured more damage.

The data on yield indicated that the dry pod yield was high in plots applied with neem cake during kharif 94 (870 kg/ha), irrigated once in 5 days during winter 94-95 (1676 kg/ha) and winter 95-96 (1118 kg/ha) and maintained completely weed free till 70 DAS during kharif 95 (986 kg/ha). There was reduction in yield by 40 to 50 per cent compared to control in plots unweeded till maturity. The mean yield was maximum in plots applied with neem cake (1144 kg/ha), irrigated once in 5 days (1121 kg/ha) and maintained weed free (1112 kg/ha) as against 906 kg in control. The increase in yield over control was 19.0 to 22.0 per cent (Table 2). The cost:benefit ratio was high in plots sown adopting 30 x 20cm spacing (1:1.53), irrigated once in 10 days (1:1.47), irrigated once in 5 days (1:1.33), maintained weed free (1:1.39) and applied with neem cake (1:1.33). However, the cultural measures namely soil application of neem cake at sowing @ 250 kg/ha, irrigation once in 5 days and maintaining weed free till 70 DAS were cost-effective in reducing the pod borers damage.

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Table 1. Influence of cultural practices in controlling groundnut pod damage due to pod borers

Treatment	Pod damage (%)					Reduction over control (%)
	Kharif '94	Winter 94-95	Kharif '95	Winter 95-96	Mean	
Soil appln.of Neem cake	4.46 (2.11)	6.55 (2.56)	3.91 (1.98)	4.86 (2.20)	4.95 (2.21)	23.75
Soil appln. of BDS	6.56 (2.56)	10.90 (3.30)	8.28 (2.88)	5.59 (2.36)	7.83 (2.78)	4.36
Soil appln. of pressmud	6.37 (2.52)	13.36 (3.66)	7.20 (2.68)	4.73 (2.17)	7.92 (2.76)	4.94
Soil appln. of *Rhizobium*	6.74 (2.60)	15.97 (4.00)	5.93 (2.44)	5.76 (2.40)	8.60 (2.86)	1.58
Irrigation once in 5 days	4.80 (2.19)	8.19 (2.86)	6.00 (2.45)	5.31 (2.30)	6.08 (2.45)	15.54
Irrigation once in 10 days	6.87 (2.62)	8.79 (2.96)	4.94 (2.22)	5.11 (2.26)	6.43 (2.52)	13.28
Spacing 30x20 cm	6.31 (2.51)	14.83 (3.85)	6.42 (2.53)	5.37 (2.32)	8.23 (2.80)	3.41
Weed free till 70 DAS	4.86 (2.20)	6.91 (2.63)	5.93 (2.44)	4.14 (2.03)	5.46 (2.33)	19.87
Unweeded till maturity	8.13 (2.85)	17.35 (4.17)	6.70 (2.59)	6.48 (2.55)	9.97 (3.04)	+ 4.65
Control	7.32 (2.71)	16.12 (4.01)	6.40 (2.53)	5.57 (2.36)	8.85 (2.90)	-

Values in parentheses are x + 0.5 transformed means.

Level of significance		Treatments	Periods	T x P
SEd	:	0.19	0.11	0.42
CD (0.05)	:	0.39	0.22	NS

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NON-PREFERENCE MECHANISM OF RESISTANCE IN GROUNDNUT CULTURES TO THE LEAF MINER *Aproaerema modicella* DEVENTER

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ABSTRACT

Oviposition non-preference of *Aproaerema modicella* was strong in the resistant cultures ICGV 86031 and ICGV 87160 (FDRS-10) both in free choice and no-choice tests. Oviposition was negatively correlated with midrib and lamina hairs of under surface of the leaf in resistant cultures. Non-preference of feeding was based on probe mines was evident in resistant ICGV 86031 and ICGV 87160. A significant positive correlation was observed between the leaflet thickness and the mining.

Key words: Groundnut leaf miner, *Aproaerema modicella*, non-preference.

INTRODUCTION

Groundnut (*Arachis hypogea* Linn.) is a major oil seed crop in India. The groundnut leaf miner (GLM), *Aproaerema modicella* Deventer (Lepidoptera: Gelechiidae), is a serious pest of groundnut and soybean in many South Asian and South East Asian countries and it is the most important groundnut pest in india (Wightman *et al.*, 1992).

Due to the increasing awareness of the pesticides, the use of resistant varieties for control of the pest is gaining importance. But the use of resistant varieties needs much background research such as agronomic suitability of the variety in the given region, yield aspects and also screening of cultivars for resistance where the nature and basis of resistance to the pest is identified. GLM resistance has been demonstrated at ICRISAT centre in a wide range of genotypes (ICRISAT, 1986). Two cultures ICGV 86031 and 87160 have shown good resistance to GLM as well as the other defoliators (ICRISAT, 1989). However, the knowledge of the principles determining resistance of these genotypes to the GLM is inadequate. The present study attempts to provide biological reasons for the resistance.

MATERIALS AND METHODS

Two GLM resistant groundnut cultures viz., ICGV 86031 and 87160 showing different degrees of resistance were studied in detail with susceptible check TMV 2. Leaf lets from 30days old plants of each culture were used for the studies. GLM culture maintained on TMV2 formed the source for the study.

Preference for feeding and oviposition

Preference for oviposition by GLM was studied by free-choice and no-choice tests.

Free-choice test

Two wooden cages (80 x 80 x 80 cm) with wire mesh on the sides and top with a wooden bottom were used for the free-choice test. In each cage 10 plants of each groundnut culture were arranged randomly and ten pairs of pupae kept in a petridish was placed inside the cage. Three days after emergence of adults, the plants were examined for the presence of batched I instar larvae for one week and the final egg count was recorded on the basis of the hatched I instar larvae, on each plant of each culture.

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No-choice test

Three wooden cages (30 x 30 x 60 cm) with wire mesh on the sides and top with a wooden bottom were used for no-choice test. In each cage four plants of the same culture were kept along with a pair of pupae. The egg count was recorded as in free-choice test. The test was repeated twice.

Leaf mining

For the feeding preference studies, the mining activity of the I instar GLM larvae was observed on the three groundnut cultures. The probe mines made by the I instar larvae before settling in their live mine were determined on the basis of the absence of the larvae in the mine but presence of little excreta in the mine made on each culture. The total number of probe mines and the live mines were counted and the number of probe mines per each live mine was worked out on each groundnut culture. The probe mines were correlated with leaflet thickness by simple correlation.

Trichomes

The trichome density counts were taken per mm^2 on the midrib and actual leaf surface (leaf lamina) directly with the help of stereoscopic microscope. Trichome counts were made on ten leaflets for each groundnut culture and each leaf constituted a replication.

Leaflet thickness

Leaflets from each groundnut culture were taken, cut transversely with the help of a fine blade. The sections were viewed through the microscope and leaflet thickness was measured with an ocular micrometer. A total of 10 sections of each culture were considered for measurement of leaflet thickness.

RESULTS AND DISCUSSION

Ovipositional preference tests

Ovipositional non-preference to resistant groundnut cultures ICGV 86031 and 87060 by GLM was evident through free-choice and no-choice tests. The resistant cultures were less preferred and the susceptible variety TMV 2 was more preferred for oviposition (Table 1). Eventhough, the free-choice test gave clear indication that GLM exhibited less preference for oviposition on resistant groundnut cultures in the presence of susceptible TMV 2, but the no-choice test confirmed that ovipositional non-preference is one of the resistant factors in the resistant cultures against GLM.

To assess the relation between the hairiness and preference by GLM, the density of hair on the midrib and lamina of the leaflet was correlated (Table 2). The resistant cultures ICGV 86031 and 87160 were more hairy with 9.10 and 8.60 trichomes per mm^2 on the midrib, respectively compared to 4.50 trichomes per mm^2 in the susceptible TMV 2. Similarly the trichome densities on the lower surface of the leaf lamina were significantly more on the resistant cultures than on the susceptible variety. Presence of higher density of trichomes in these preferred sites for oviposition may be the cause for reduced oviposition in the resistant cultures. A significant negative correlation was observed between the midrib trichome density and the number of eggs laid under free-choice ($r = -0.9615$) and a non-significant negative correlation under no-choice ($r = -0.8937$) conditions. Similarly, the correlation between leaf lamina trichome density and ovipositional preference by GLM was significantly negative under free-choice ($r = -0.9817$) and non-significantly negative in no-choice ($r = -0.8515$) conditions. The correlation between oviposition and trichome density indicate that trichomes are deterring factor for oviposition.

Leaf mining

Leaf mining habit varied with resistance. The susceptible cultivars had single live mine and larva settled in the first mine it made and no probe mines have been noticed. The resistant groundnut cultures had more probe mines as against single live mine in the susceptible variety indicating that these cultures were not preferred by the neonate (I instar) larvae initially when it commences feeding.

The leaflet thickness was found to be significantly high in one of the resistant lines ICGV 86031 (93.58 u) compared to ICGV 87160 (88.39 u) and the susceptible variety TMV 2 (73.99 u). A significant positive correlation (r = 0.9808) was observed between the thickness and the mining indicating that higher the leaflet thickness the more the number of probe mines.

Neonate larval mortality was significantly high in the resistant cultures ICGV 86031 (18%) and ICGV 87160 (16%) compared to the susceptible TMV 2 (3%) (Table 3). High larval mortality indicated the antibiosis effects due to resistant groundnut cultures. Similarly Ezuech (1981) and Rufener *et al.* (1986) reported the pronounced mortality of cowpea moth larvae on the resistant varieties. Correlation coefficient values between the trichome density on the midrib, leaf surface and I instar mortality were significant and positive.

Midrib trichomes	Lamina trichomes
r = 0.9754**	r = 0.9526**

Similar report has also confirmed the results (Everson and Ringlund, 1968)where higher first instar larval mortality in the case of cereal leaf miner *Oulema melanopus* on densely pubescent wheat leaves.

The correlation between the leaflet thickness and the I instar GLM mortality also showed significant positive relationship (r = 0.9893*).

Non-preference mechanism for egg laying and feeding was evident in both the resistant cultures ICGV 86031 and 87160. Both morphological and anatomical characters are the contributory factors for resistance in these cultivars against the GLM.

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Table 1: Ovipositional preference of groundnut leaf miner (GLM) to groundnut cultures by free-choice and no-choice tests

Groundnut cultures	Number of eggs/female	
	Free-choice	No-choice
TMV 2	22.90	36.33
ICGV 86031	15.76	30.00
ICGV 87160	18.42	26.40
S.E (d) +	0.5704	0.6108
C.D (0.05)	1.2428	1.3310

Table 2: Trichome density on the midrib of the *leaflet and lamina of susceptible and* resistant groundnut cultures to GLM.

Groundnut cultures	Trichome density/mm²	
	Midribs	Leaf lamina (lower)
TMV 2	4.50	15.60
ICGV 86031	9.10	25.30
ICGV 87160	8.60	23.40
C.D (0.05)	0.7424	

Table 3. ***Instarwise larval and pupal mortality of GLM and per cent adult emergence on susceptible* and resistant groundnut cultures.**

Groundnut cultures	Percentage of instar mortality							Adult emergence
	GLM larval instars							
	I	II	III	IV	V	Pupa	Total	
TMV 2	3 (9.38)	-	-	-	-	1 (4.07)	4 (11.54)	96
ICGV 85031	18 (25.10)	2 (8.13)	-	-	-	6 (14.18)	26 (30.66)	74
ICGV 87160	16 (23.58)	2 (8.13)	-	2 (8.13)	-	8 (16.43)	28 (31.95)	72
C.D (0.05)	2.892							

Values in parenthesis are the transformed values
Mean of 50 larvae and pupae.

Table 2. Effect of cultural practices on the pod yield of groundnut.

Treatment	Pod yield (kg/ha)					Increase over control (%)	C : B ratio
	Kharif 1994	Winter 94-95	Kharif 1995	Winter 95-96	Mean		
Soil appln. of Neem cake	870	1668	961	1075	1144	22.82	1 : 1.33
Soil appln. of BDS	642	1465	921	997	1006	8.08	1 : 0.97
Soil appln. of pressmud	618	1605	883	991	1024	10.02	1 : 1.09
Soil appln. of *Rhizobium*	665	1616	952	1018	1062	14.15	1 : 1.21
Irrigation once in 5 days	793	1676	899	1118	1121	20.46	1 : 1.36
Irrigation once in 10 days	537	1506	912	1001	989	6.23	1 : 1.47
Spacing 30x20 cm	583	1530	901	1040	1013	8.86	1 : 1.53
Weed free till 70 DAS	735	1639	986	1088	1112	19.40	1 : 1.39
Unweeded till maturity	128	798	633	628	546	-41.27	1 : 1.27
Control	560	1242	867	955	906	-	1 : 1.27

Level of significance		Treatments	Periods	TxP
SEd	:	59	36	128
CD (0.05)	:	118	75	261

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CONTROL OF POD BORERS OF GROUNDNUT BY SOIL APPLICATION OF INSECTICIDES IN AFLISOLS

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ABSTRACT

Different formulations of insecticides were assessed for their toxicity against pod borer complex, (earwig, wire-worm and blind ant) of groundnut for four seasons under red lateritic soil conditions. Soil application of carbofuran 3G, phorate 10G @ 10 kg/ha and quinalphos 1.5D @ 25 kg/ha twice at the time of sowing and 45 DAS were effective in controlling the pod borer complex and recorded 60.94, 46.43 and 32.43 per cent less pod damage and 33.58, 32.02 and 17.50 per cent higher yield over untreated control with C:B ratio of 1:1.37, 1:1.71 and 1:1.24, respectively.

Key words: Groundnut; pod borers; control; insecticides; alfisols.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oil seed crop in India, occupying 45 per cent of India's total oil seed production. Although more than 50 species of insect and non-insect pests were reported to cause damage to groundnut, only few are significantly important, as their attack result in large reductions in pod yield (Wightman and Ranga Rao, 1993). Pod borers are becoming economically important pests in some pockets of India causing direct economic losses, as the penetrated pods are of little commercial value. Wightman and Amin (1988) reported that whitegrubs, termites, millipedes, wireworms, blind ants and earwigs bore holes in developing groundnut pods throughout the semi-arid tropics. However, earwig, *Euborellia stali* (Cherian and Basheer, 1940), false wireworm, *Penthicoides seriatoporus* Fair (Kapadia, 1994) and termites, *Odentotermes obesus* (Kaushal and Deshpande, 1967) were reported as major pod borers in India, inflicting 20, 25 and 46 per cent pod damage, respectively. Under red lateritic soils (alfisols) of Pudukkottai district of Tamil Nadu, the authors have observed regular occurrence of earwig and wireworm (sp. unidentified) and sporadic occurrence of the blind ant, *Dorylus* sp. in groundnut. These pod borers complex caused 6 to 15 per cent of pod damage. The insecticides namely chlordane 5D (Melamed Madjar and Shalomo, 1970), heptachlor 5D and 10 D (Barwal and Gupta, 1991) which were found effective against the earwing in groundnut, are now either completely banned from use or banned from use in oilseeds. Thus, the present study was made to evaluate different formulations of insecticides which are under current use through soil application, as the pod borers inhabited the soil.

MATERIALS AND METHODS

Field trials were conducted at National Pulses Research Centre, Vamban, Pudukkottai district of Tamil Nadu under irrigated conditions using the groundnut variety TMV 7 in red lateritic soils consecutively for four seasons during kharif 1994, winter 1994-95, Kharif 1995 and winter 1995-96. There were three replications in randomized block design with a plot size of 5 x 4m. Different formulations of insecticides namely phorate 10 G, carbofuran 3G, sevidol 4:4G (Granules) @ 10 kg/ha, carbaryl 5D, Quinalphos 1.5D, methyl parathion 2D, fenvalerate 4D (Dusts) @ 25 kg/ha, dichlorvos @ 1.0 lit/ha and chlorpyriphos @

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2.5 lit/ha (liquid) were evaluated. The dust and granular insecticides were applied twice at the time of sowing and 45 DAS (at gypsum application) to the soil. Chlorpyriphos and dichlorvos were applied through irrigation after sowing and at gypsum application.

The pod damage due to pod borer complex was assessed at the time of harvest on the basis of per cent infested and bored pods. The pod yield was recorded after harvesting and drying of the pods. The data on pod damage and yield for four seasons were analysed statistically. The cost: benefit ratio for all the insecticides was worked out.

RESULTS AND DISCUSSION

During Kharif 94, 95 and winter 95-96, the earwigs and wireworms were the only pod borers observed. Pod damage due to blind ant, *Dorylus* sp was also noted besides earwig and wireworms during winter 94-95. The symptoms of damage due to earwig and wireworm were similar as reported by Purushothaman *et al.* (1970) and Wightman and Ranga Rao (1993), respectively. The blind ant scraped the shell and bored either spherical or round holes (3 to 5 mm in dia.) mostly at the beak site and fed on kernels. The infested pods were either empty or filled with sand particles.

Application of carbofuran was found effective against all pod borers and recorded low pod damage of less than 2.5 per cent in all the seasons. During kharif 94 phorate, chlorpyriphos and fenvalerate were the effective insecticides next only to carbofuran against earwig and wireworms with 0.68, 2.47 and 2.93 per cent pod damage, respectively, while control recorded 10.22 per cent damage. Earwig, wireworms and blind ants were the pod borers noted during winter 94-95 and fenvalerate, chlorpyriphos and phorate were the effective insecticides besides carbofuran against these pod borers with low pod damage (2.03%, 2.17% and 3.36%, respectively). The untreated control registered 16.14 per cent pod damage as against 0.75 per cent in carbofuran. Quinalphos 1.5 D during kharif 95 (2.06%) and fenvalerate (1.93%) and phorate (1.83) during winter 95-96 were the other insecticides next to carbofuran and recorded low pod damage due to earwig and wireworms (Table 1). The untreated control registered 6.52 and 9.86 per cent pod damage during kharif 95 and winter 95-96, respectively.

Pooled data showed that all the insecticides were superior to control in controlling the pod borer complex in groundnut. However, plots applied with carbofuran @ 10 kg/ha twice at the time of sowing and 45 DAS alone recorded significantly low pod damage due to pod borer complex (1.16%) which was 60.94 per cent less than control (9.86%). The other effective insecticides were phorate (1.70%), fenvalerate (2.72%), chlorpyriphos (2.69%) and quinalphos (4.24%) which recorded 46.43, 43.77, 43.69 and 32.43 per cent less damage than control (Table 1).

The dry pod yield was higher during winter than in kharif season. The pod yield was maximum in carbofuran treated plots during kharif 94 (970 kg/ha), kharif 95 (982 kg/ha) and winter 95-96 (1196 kg/ha) and phorate during winter 94-95 (1672 kg/ha), while control registered 573, 772, 960 and 1283 kg/ha, respectively. Pooled data showed that the yield was maximum in carbofuran (1198 kg/ha) followed by phorate (1184 kg/ha) and fenvalerate (1104 kg/ha), which was 33.58, 33.02 and 23.10 per cent higher than control (897 kg/ha) (Table 2). The cost:benefit ratio was high in phorate (1:1.71), carbofuran (1:1.37) and quinalphos (1:1.24) and thus the application of these three insecticides alone were economical.

Earlier findings indicated that soil application of chlordane 5D (Melamed-Madjar and Shalomo, 1970), DDT 5D (Padmanabhan *et al.*, 1973), heptachlor 5D and BHC 10D (Barwal and Gupta, 1991) were effective in reducing the infestation of *E. stali* in groundnut. The present study indicated that soil application of carbofuran 3G, phorate 10G @ 10 kg/ha and quinalphos 1.5 D @ 25 kg/ha twice at the time of sowing and 45 DAS (at gypsum application) were cost-effective in reducing the pod damage due to pod borer complex (earwing, wireworms and blind ants).

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Table 2. Effect of soil application of different insecticides on the yield of groundnut.

Insecticide	Pod yield (kg/ha)						
	Kharif 1994	Winter 95-95	Kharif 1995	Winter 95-96	Mean	Increase over control (%)	C:B ratio
Phorate 10G,10kg/ha	910	1672	980	1175	1184	32.02	1:1.71
Carbofuran 3G,10kg/ha	970	1545	982	1196	1198	33.58	1:1.37
Sevidol 4.4G, 10kg/ha	583	1157	872	1040	1018	13.49	1:0.89
M.Parathion 2D,25kg/ha	653	1602	837	1066	1039	15.89	1:1.21
Carbaryl 5D, 25kg/ha	677	1618	921	1031	1061	18.37	1:1.04
Quinalphos 1.5D, 25kg/ha	700	1562	836	1118	1054	17.50	1:1.24
Fenvalerate 4D. 25kg/ha	875	1583	821	1138	1104	23.10	1:0.97
Dichlorvos 1.ol/ha	723	1562	861	1101	1061	18.37	1:1.23
Chlorpyriphos 2.5l/ha	817	1627	909	1031	1096	22.19	1:0.89
Control	573	1283	772	960	897	-	

Level of significance		Treatments	Periods	Tx P
SED	:	44	28	93
CD(0.05)	:	89	58	187

Table 1. Effect of soil application of insecticides in controlling pod damage due to pod borer complex.

Insecticide	Pod damage (%)					
	Kharif '94	Winter 94-95	Kharif '95	Winter 95-96	Mean	Reduction over control (%)
Phorate 10G, 10kg/ha	0.68 (1.09)	3.36 (1.96)	4.37 (2.21)	1.83 (1.52)	2.56 (1.70)	46.43
Carbofuran 3G, 10kg/ha	0.00 (0.71)	0.79 (1.14)	2.40 (1.70)	1.46 (1.40)	1.16 (1.24)	60.94
Sevidol 4:4G, 10kg/hg	4.61 (2.26)	8.09 (2.93)	4.09 (2.14)	4.91 (2.33)	5.43 (2.41)	23.72
M.Parathion 2D,25kg/ha	3.51 (2.00)	8.44 (2.99)	4.44 (2.22)	4.99 (2.34)	5.35 (2.39)	24.52
Carbaryl 5D 25, kg/ha	4.48 (2.23)	8.18 (2.95)	4.00 (2.12)	2.29 (1.67)	4.74 (2.24)	29.17
Quinalphos 1.5D.25kg/ha	5.31 (2.41)	6.41 (2.63)	2.06 (1.60)	3.18 (1.92)	4.24 (2.14)	32.43
Fenvalerate 4D, 25kg/ha	2.93 (1.85)	2.03 (1.59)	3.99 (2.12)	1.93 (1.56)	2.72 (1.78)	43.77
Dichlorvos 1.0 lit/ha	5.31 (2.41)	11.42 (3.45)	3.83 (2.08)	2.76 (1.81)	5.83 (2.44)	23.01
Chlorpyriphos 2.5 lit/ha	2.47 (1.72)	2.17 (1.63)	3.16 (1.91)	2.90 (1.86)	2.69 (1.78)	43.69
Control	10.22 (3.27)	16.14 (4.08)	6.56 (2.66)	6.52 (2.65)	9.86 (3.17)	

Values in parenthesis are $\sqrt{x + 0.5}$ transformed means

Level of significance		Treatments	Periods	Tx P
SED	:	**0.29**	**0.11**	**0.62**
CD (0.05)	:	**0.58**	**0.23**	**NS**

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EFFECT OF ENVIRONMENTAL FACTORS ON MUSTARD APHID (*Lipaphis erysimi* Kalt.) INFESTATION IN DIFFERENT GERMPLASM OF INDIAN MUSTARD, *Brassica juncea* (L.) COSS*

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ABSTRACT

The effect of seven environmental factors on mustard aphid infestation in 75 germplasm lines of Indian mustard (selected from 726 diverse germplasm through preliminary screening)were studied in timely and late sown condition. The mean aphid infestation index (MAII) was significantly and negatively correlated with maximum temperature, evaporation, sunshine, and wind velocity, and it was significantly and positively correlated with maximum relative humidity under both the conditions and with minimum relative humidity under timely sown condition only. The parameters average-maximum temperature around 23°C, minimum temperature around 10°C, maximum relative humidity from 85 to 88%, minimum relative humidity from 30 to 35%, sunshine from 4 to 7 hr/day, evaporation from 2 to 3 mm/day and wind velocity from 3 to 4.5 km/hr/day were found to be the most congenial for increase of aphid population under field condition. For effective screening of Indian mustard germplasm against mustard aphid infestation it is necessary to have such a congenial weather condition.

Key words : *Brassica*, environment, mean aphid infestation index, mustard aphid.

INTRODUCTION

The mustard aphid (*Lipaphis erysimi*), is a major pest of indian mustard. This aphid is the most important cause for limiting both productivity and production of rapeseed-mustard (Vir and Henry, 1987 and Nath and Saha, 1974). Although the pest is amenable to control by insecticides (Raj and Ramakrishnan, 1982), the cost of pesticides on commercial scale is prohibitive apart from the harmful effects of insecticides on environment. Growing plant varieties that are resistant to mustard aphid is an ideal measure to protect the crop against insect damage. The present investigation is an effort to examine the effects of weather parameters on the aphid infestation and to know the congenial environmental condition to screen large germplasm of Indian mustard for resistance to mustard aphid.

MATERIALS AND METHODS

The diverse germplasm of Indian mustard comprising 726 entries were obtained from National Bureau of Plant Genetic Resources, New Delhi and were used for preliminary screening in the rabi season of 1988-89. Finally 75 entries showing lower infestation score for aphid density were subjected to rigorous screening along with 10 check entries at Research Farm, Indian Agricultural Research Institute, New Delhi during 1989-90 rabi season at two dates of sowing viz., timely (1st week of November) and late (3rd week of NOvember). Entries were replicated twice with each plot of 2m length spaced planted at distance of 40 x 20 cm. Randomly selected 10 marked plants per plot were taken as sample to assign the grades at weekly interval

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using 0-5 scale of Bakhetia and Sandhu (1973). These grades were utilized to calculate the mean aphid infestation indices (MAII) following the method of Rajan (1961). Relevant weather data at weekly interval on temperature (°C), relative humidity (%), rainfall (mm), evaporation (mm/day), sunshine (hours/day), and wind velocity (Km/hr/day) were collected to assess the influence of environmental factors on mustard aphid infestation.

RESULTS AND DISCUSSION:

Influence of important weather parameters namely temperature, relative humidity, evaporation, sunshine and wind velocity on aphid were examined (Fig 1 and 2). Mean aphid infestation index (MAII) was significantly negatively correlated with maximum temperature, sunshine, evaporation and wind velocity under timely and late sown conditions (Table 1). The correlation between MAII and minimum temperature was positive and non significant ($r = 0.111$, Table- I) the regression coefficient 0.067 indicates very less influence of it under late sown condition in comparison with timely sown condition ($r = -0.725$ and $b = -1.95$, Table 1). The parameters namely maximum and minimum relative humidity were positively correlated with mean aphid infestation index (MAII) under both the conditions. The relationship between MAII and weather conditions indicates that with the increase in relative humidity and decrease in temperature, evaporation, sunshine and wind velocity there was increase in aphid infestation.

The maximum temperature under timely and late sown condition ranged from 20.57 to 25.68 °C and 19.58 to 29.90°C (Fig 1 and 2). With progressive decrease in temperature there was corresponding increase in aphid population. Landin and Wennergen (1987) observed that there was greatest increase of aphid, *Lipaphis erysimi* on *Brassica juncea* at different constant temperatures from birth to death. The rate of increase was the highest at 25°C. Lawson (1941) reported that the rate of reproduction was the highest at 20°C and it decreased with increasing temperature. And beyond 30°C temperature the reproduction of aphid stopped altogether.

In the present study the average maximum temperature did not go beyond 25.90°C and average minimum temperature ranged from 9.60 to 11.20°C and 10.57 to 11.28°C under timely and late sown conditions, respectively. Average minimum temperature around 10°C and average maximum temperature around 23°C appeared to be the most congenial for increase of aphid population under both the conditions.

Average maximum and minimum relative humidity had positive relationship with MAII. The parameters, average minimum relative humidity from 30 to 35%, average maximum relative humidity from 85 to 88%, average sunshine from 4 to 7 hr/day, average evaporation from 2 to 3 mm/day and average wind velocity from 3 to 4.50 km/hr/day were found to be the most congenial for increase in aphid infestation. Bakhetia and sidhu (1983) found that fecundity, longevity and reproduction of aphid per day remained constant at mean minimum and maximum temperature and relative humidity i.e., 7 to 9.2°C, 22.6 to 25.0°C and 53 to 93%, respectively. Higher temperature above 30°C and sub-zero winter temperature had adverse effect on the population of mustard aphid.

The parameters viz.,evaporation, sunshine and wind velocity showed significant inverse relationship with MAII under both the conditions. With the decrease in evaporation, there was corresponding increase in aphid infestation. The increase in evaporation from soil is directly related to availability of water to plant. The reduction in availability of water in host's cell sap, would have adversely affected feeding behavior of aphid. However, effect of evaporation can not be considered in isolation from sunshine and wind velocity which have profound influence.

The relationship of important weather parameters with aphid infestation index in the present investigation suggest that for screening of Indian mustard germplasm against mustard aphid infestation, it is necessary to have such quite congenial environment condition to determine variability in the genotypes for resistance to the aphid.

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Table 1. Correlation and regression coefficients between different weather parameters and mean aphid infestation index (MAII) under timely sown and late sown conditions in indian mustard.

Parameters	Correlation coefficient 'r'		Regression	
	Timely sowing	Latesowing	Timely sowing	Late sowing
Maximum temperature Vs MAII	-0.90**	-0.680**	Y = 17-0.604x	Y = 11.94-0.356x
Minimum temperature Vs MAII	-0.725**	0.111	Y = 15.35-1.95x	Y = 2.85+0.067x
Maximum relative humidity Vs MAII	0.775**	0.775**	Y = -15.12+0.207x	Y = -12.69+0.188x
Minimum relative humidity Vs MAII	0.696**	0.705**	Y = -0.27+0.069x	Y = 0.64+0.066x
Sunshine Vs MAII	-0.514*	-0.629**	Y = 4.85-0.326x	Y = 5.78-0.359x
Evaporation Vs MAII	-0.916**	-0.717**	Y = 6.12-1.228x	Y = 5.97-0.834x
Wind velocity Vs MAII	-0.687**	-0.577**	Y = 6.14-0.774x	Y= 6.97-0.761x

* Significant at 5% ** Significant at 1% level

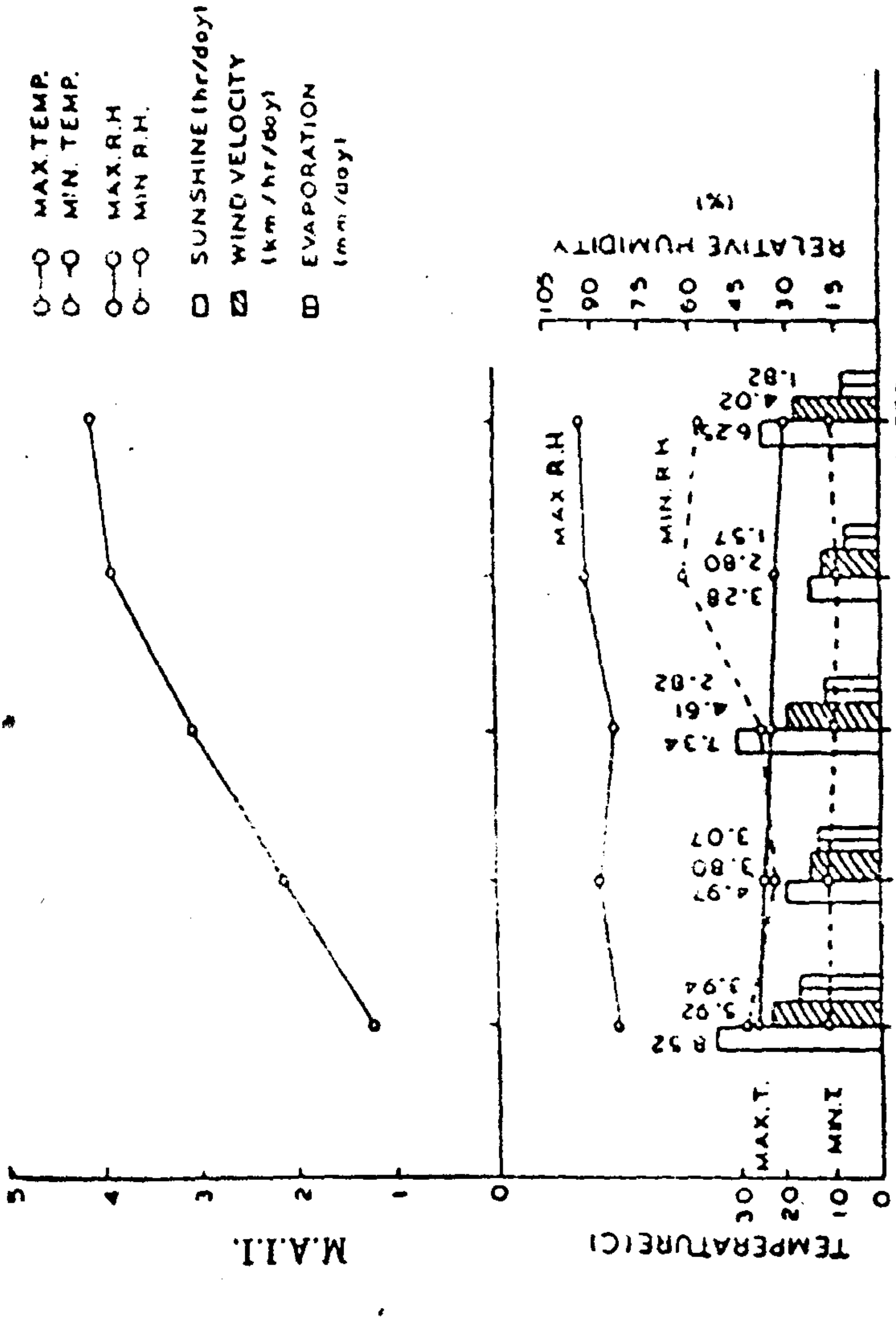

Fig -1 : Relation between weather parameters and aphid infestation index (Timely sown)

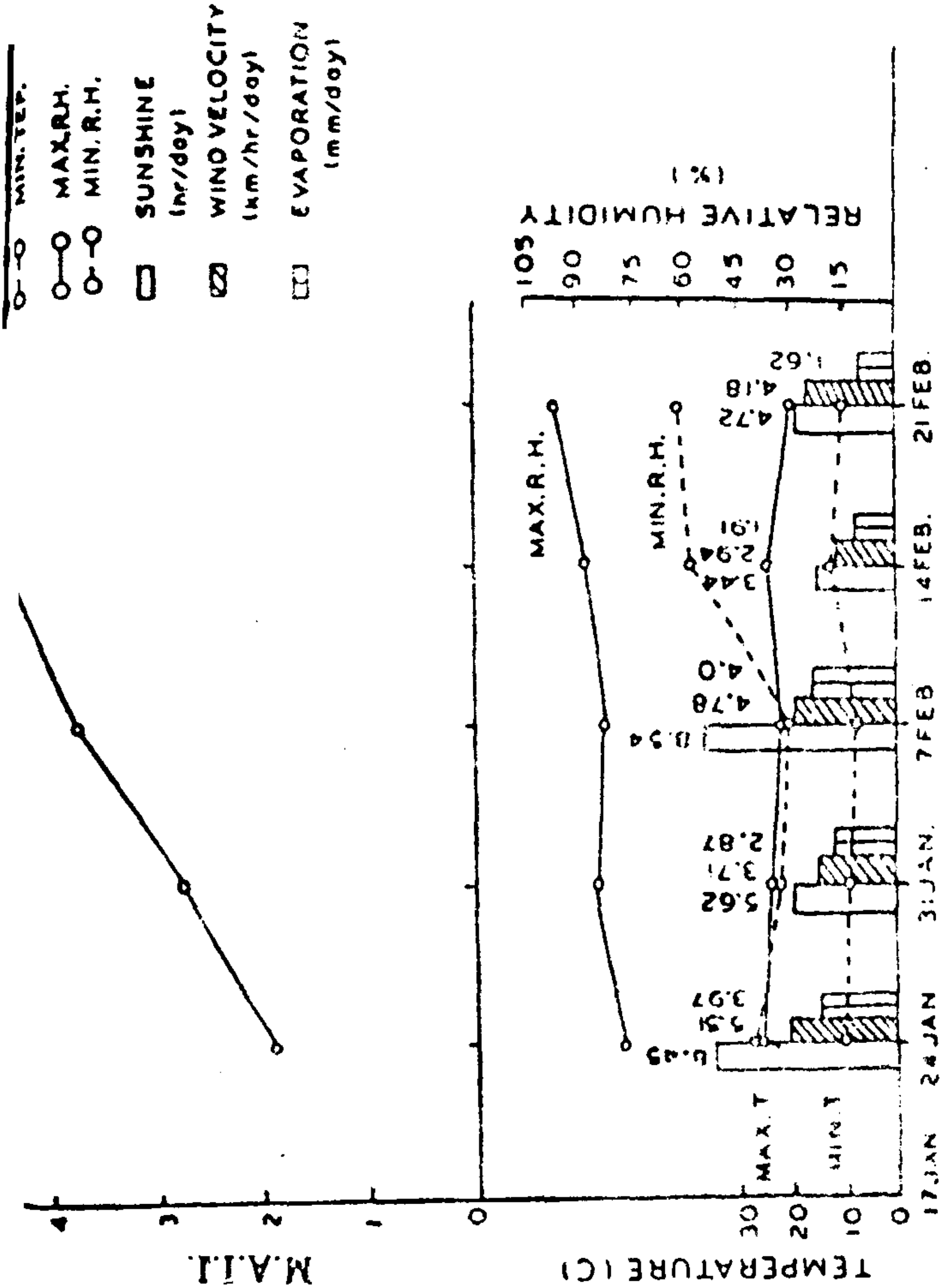

Fig-2 : Relation between weather parameters and aphid infestation index (Late sown)

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IDENTIFICATION OF RESISTANT SOURCES TO SAFFLOWER APHID

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ABSTRACT

The experiments under field and caged conditions were conducted with 9 promising safflower germplam lines to identify the genotypes with high degree of tolerance to aphids. On the basis of aphid population, foliage drying grades, yield and morphological characters displayed at different locations, six entries viz., SSF-268. GMU-3644, 3955, 4480, 4484 and JLSF-322 were identified as tolerant to aphids and recommended for their exploitation in breeding programmes, aimed at evolving high yielding genotypes or varieties with better resistance to aphids, particularly for rainfed safflower.

Key words: Resistant sources, safflower, aphid.

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is one of the important oilseed crops of India grown in rabi season. The productivity of safflower in India is low (543 kg/ha). One of the important reasons for low productivity is that the crop is affected by a number of insect-pests and diseases. Among different insect pests, aphid (*Uroleucon compositae* Theobald) is the only noxious pest of the crop (Akahses *et al.*, 1992 and Ghorapade *et al.*, 1994) which is reported to be causing 35 to 72 per cent loss in yield during heavy infestation periods (Suryawanshi and Pawar, 1980). The control of this pest through insecticides is possible but owing to hazardous effect they need to be used along with other methods of control. Evaluation of high yielding safflower varieties with resistance to aphid would be the safest and cheapest method for aphid control. With this objective, an investigation has been carried out to identify aphid resistant sources to be exploited in breeding programme. Some of the earlier workers also (Naik, 1987; Parlekar and Ghorpade, 1992 and Akashe *et al.*, 1993 and 1994) identified tolerant sources to safflower aphid.

MATERIAL AND METHODS

In the rabi season of 1994-95, 19 promising entries promoted from uniform pest nursery experiment were screened against aphid at 4 different locations (Solapur, Jalgaon, Annigeri and Indore) under both field and cage conditions. Of these, 9 entries which exhibited tolerance to aphids were studied for knowing the stability in resistance during the winter season of 1995-96. The performance of 9 entries was compared with both susceptible (CO-1) and national (A-1) checks by adopting a new method of computing Aphid Infestation Index (A.I.I.) to categorise the entries under different foliage drying grades (Table-1).

$$AII = \frac{1 \times a + 2 \times b + 3 \times c + 4 \times d + 5 \times e}{a + b + c + d + e + \ldots + j}$$

Where, 1 to 5 = Different foliage drying grades

a to j = No. of plants in each grade

The identified 9 entries along with susceptible (CO-1) and national (A-1) checks were sown one month late after the normal sowing under field conditions in a randomised block design with three replications at Solapur, Jalgaon,

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Table 1. **Method of scoring the entries.**

%Drying of foliage (range)	Grade	Category of the entry	Aphid Infestation Index (A.I.I.)
0 to 20	1	Highly tolerant	1
21 to 40	2	Tolerant	1.1 to 2.0
41 to 60	3	Moderately tolerant	2.1 to 3.0
61 to 80	4	Susceptible	3.1 to 4.0
Above 80	5	Highly susceptible	4.1 to 5.0

Annigeri and Indore. Each treatment was planted in a single row of 5m length with spacing of 45 x 20 cm. The susceptible check was also grown all around each experimental block/replication as an infester for maximum build-up of aphids.

The data on actual aphid count of 5 cm apical twig/plant of five randomly selected plants from each entry were collected at peak aphid incidence i.e. about one month after the first incidence. The per cent aphid population in each entry was compared with A1 check (100%). The observations were also recorded by visual score method based on premature foliage drying due to the pest infestation of whole plant on 1 to 5 grades (Table 1) one month after peak incidence. The seed yield was recorded at harvest. Besides, observation on morphological and other characters like days to 50% flowering, spininess, plant height, colour of leaves etc. were also recorded to assess the relation between plant characters and degree of infestation by aphids.

These 9 entries were also tested under the artificial infestation of aphid in cages at two locations (Solapur and Indore). Plants were grown in earthen pots and covered with thick plastic cages of 60 x 25 cm size from the germination till the recording of aphid number. Ten 1 to 2 day old nymphs/plant were released at elongation stage and pots were completely covered with polythene cages. The total aphid population was recorded one month after the release. The means were pooled, % increase or decrease in population over A-1 was calculated.

RESULTS AND DISCUSSION

Field study

The pooled results (Table 2) showed that none of the entries showed high tolerance. However, 6 entries viz., GMU-3944, 3955, 4480, 4484, JLSF-322 and SSF-268 rated tolerant (1.1 to 2.0 A.I.I.). A-1 was rated moderately tolerant (2.9AII), whereas the susceptible check (CO-1) possesed A.I.I. of 4.8. Most of the entries produced yield almost equal to or more than A-1 variety. The maximum seed yield of 7.0 g/plant was recorded from GMU-3944 as against 6.2 g/plant in A-1.

It was also observed that all the entries harboured less number of aphids at peak incidence than A-1. All these entries also showed the aphid population between 65.7 and 99.6 per cent as compared to 100% in A-1. The lowest aphid population (161/plant) was observed on the entry GMU-4480 followed by SSF-268 (163) and GMU-3944 (164) as against 245 aphids/plant in A-1. The suseceptible check (CO-1) possessed 358 aphids/5 cm twig recording 146.1 % higher aphid population than A-1 (Table 2).

With regard to morphological and other characters, all the entries required less number of days to 50% flowering than A-1 and CO-1 except GMU-4499(84) which was at par with A-1 and CO-1. The entry GMU-3944 attatined 50% flowering in 77 days followed by GMU-4484 (79), GMU-4522 (79) and GMU-3955(80). All the entries possessed less plant height than A-1 (Table-2). Morphologically it was observed that the entries with spines, medium plant height, green coloured less succulent, narrow and leathery leaves, thick and hard stem were less suseptible to aphids.

Cage study

All the entries showed less aphid multiplication rate (Table 3) as compared to susceptible check (CO-1). Also, all the entries except GMU-4499 showed decrease in aphid population than A-1. However, the maximum per cent decrease in aphid population over A-1 was observed in the entry SSF-268 (39.1) followed by GMU-4480 (33.5) and GMU-3955 (31.0).

From the above studies it is concluded that 6 entries viz., SSF-268, GMU-3944, 3955, 4480, and JLSF-322 consistently exhibited tolerance against aphids. These stable aphid tolerant sources can be utilised in the breeding programmes to develop high yielding safflower varieties with better tolerance to aphids.

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Table 2. Mean performance of promising safflower entries for aphid tolerance (Field studies: 1995-96)

Entry	Aphids on 5cm apical twig/plant	%aphid population to check (A-1)	Foliage drying (AII)	Category	Seed yield (g/plant)	Days to 50% flowering	Plant height (cm)	Spiny/non-spiny	Leaf colour
GMU-3944	164	66.9	1.4	T	7.0	77	66.5	Spiny	Palegreen
GMU-3955	166	67.8	1.5	T	5.7	80	61.0	Spiny	Pale green
GMU-4480	161	65.7	1.8	T	3.9	81	70.9	Spiny	Green
GMU-4484	177	72.2	2.0	T	5.0	79	72.6	Spiny	Green
GMU-4499	191	78.0	2.8	MT	6.5	84	65.9	Spiny	Green
GMU-4522	244	99.6	2.8	MT	5.5	79	63.5	Spiny	Green
JLSF-318	177	72.2	2.2	MT	5.2	81	64.4	Spiny	Green
JLSF-322	193	78.8	1.7	T	4.8	82	74.1	Spiny	Green
SSF-268	163	66.5	1.9	T	5.1	81	73.2	Spiny	Green
A-1(NC)	245	100.0	2.9	MT	6.2	84	74.7	Spiny	Green
CO-1 (SC)	358	146.1	4.8	HS	1.0	84	77.8	Nonspiny	Dark-green

T=Tolerant, MT= Moderately Tolerant, HS = Highly susceptible, NC= National check. SC=Susceptible check, AII= Aphid infestation index.

Table 3. Effect of aphid population on promising safflower entries under artificial epiphytotic conditions (cage study: 1995-96)

Entry	Aphid multiplied on one plant			Average % decrease (-) or increase (+) in aphid population overnational check
	Solapur	Indore	Mean	
GMU-3944	1291	517	904	-22.2
GMU-3955	1101	503	802	-31.0
GMU-4480	1106	439	773	-33.5
GMU-4484	1454	422	938	-19.3
GMU-4499	1687	681	1184	+2.0
GMU-4522	1509	598	1054	-9.3
JLSF-318	1256	433	845	-27.3
JLSF-322	1152	513	833	-28.3
SSF-268	1093	323	708	-39.1
A-1(NC)	1653	670	1162	0.0
CO-1(SC)	2013	887	1450	+24.8

NC - National check; SC - Susceptible check

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INFLUENCE OF SULPHUR AND BENZYLADENINE ON GROWTH AND PRODUCTIVITY IN SUNFLOWER.

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ABSTRACT

Effect of sulphur and benzyladenine on drymatter production and yield in sunflower was studied in two field experiments during Kharif, 1992 and 1993. Sulphur at 45 kg ha-1 and benzyladenine at 60 ppm recorded significantly higher values for total drymatter, leaf area duration and chlorophyll index. The yield components viz., number of filled seeds per capitulum, test weight, seed yield, protein content and oil content were also significantly influenced by sulphur and benzyladenine compared to untreated control.

Key words: Sunflower, drymatter, LAD, chlorophyl index, protein, oil, yield.

INTRODUCTION

In recent years sunflower gained importance due to its wider adaptability and rich source of polyunsaturated fatty acids. However, decreased productivity is attributed to inadequate seed filling related to source-sink concept (Sirohi and Abrol, 1991). The present paper, deals with the effect of sulphur and benzyladenine on drymatter production, leaf area duration, chlorophyll index, protein, oil content and yield of sunflower.

MATERIALS AND METHODS

Two field experiments were conducted during monsoon 1992 and 1993 on sandy loam soil low in sulphur (19.0 kg ha-1) at Agricultural College Farm, Rajendranagar, Hyderabad following Factorial randomised block design with sixteen treatments. The treatments consisted of sulphur (15, 30 and 45 kg ha^{-1}) in the form of ammonium sulphate and benzyladenine (20, 40 and 60 ppm) and control.

The variety Morden was sown in plots measuring 4.5 m x 3.0 m with spacing of 45 cm x 30 cm. Entire sulphur in the form of ammonium sulphate was applied as basal, where as benzyladenine was sparayed on 35th and 55th day after sowing. A common dose of NPK @ 20, 40, 30 kg ha^{-1} , respectively was applied just before sowing as basal dose and a dose of N @ 30 kg ha^{-1} was applied in two splits at 30 and 45 DAS.

Five plants within a row were tagged and data on plant height, number of leaves and number of seeds per plant were recorded. Plants from one square meter were sampled at 15, 30, 45, 60 DAS and at harvest to estimate chlorophyll content and to record leaf area and total plant drymatter. The data were used to calculate the leaf area duration and chlorophyll index (Sestak *et al.*, 1971).

RESULTS AND DISCUSSION

Sunflower plants are considered to be deficient in sulphur when its value is less than 0.25% (Singh and Sahu, 1986). Application of sulphur (40 kg ha-1) is, therefore, essential to maintain its critical levels in different plant organs (Sagare *et al.*, 1990). Sulphur (45 kg ha^{-1}) and benzyladenine (60 ppm) have significantly increased total drymatter production in sunflower during both the years (Table 1). The per cent increase in the total drymatter due to sulphur and benzyladenine over control at harvest was 29 and 27 per cent, respectively in both the years. This increase in total drymatter production was

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attributed to RNA-DNA and chlorophyll induced changes on photosynthesis with the application of sulphur and benzyladenine (Naito *et al.*, 1978; Goswami and Srivastava, 1987 and Sagare *et al.*, 1990).

Among the treatments, sulphur (45 kg ha-1) and benzyladenine (60 ppm) increased the values for LAD and chlorophyll index (Table 2) suggesting that sulphur increases the availability of iron and makes it physiologically more active for biosynthesis of porphyrin (Singh and Singh, 1983) and thereby chlorophyll (Khanpara, 1993). Increase in chlorophyll synthesis due to benzyladenine was attributed to the increase in number of chloroplasts per cell and stimulation of amino nitrogen (Goswami and Srivastava, 1988). Benzyladenine makes the leaf more functional by delaying the loss in chlorophyll and thereby increases the nitrate reductase activity of leaves in sunflower (Goswami and Srivastava, 1989). Stability in chlorophyll index due to delayed senescence was also reported when benzyladenine was applied @ 100 ppm (Sirohi and Abrol, 1991).

Sulphur and benzyladenine significantly influenced number of filled seeds, filling per cent, test weight and seed yield (Table 3). In both the years the per cent seed set was 82 with sulphur at 45 kg ha^{-1} and 81 with BA at 60 ppm compared to the value of 74 to 76 in untreated controls. The increase in number of seeds due to high per cent of seed set can be attributed to adequate supply of sulphur and adenine compounds which help in prevention of floral abortion and establishment of larger number of potential seeds (Hocking *et al.*, 1987). Such beneficial effects in the present study increased the seed yield to an extent of 27 and 23 per cent with sulphur (45 kg ha^{-1}) and benzyladenine (60ppm), respectively compared to control in both the years. The quality parameters viz., protein and oil composition were significantly influenced by sulphur. Its application might have increased the activity of acetic-thiokinase, an important enzyme necessary for conversion of acetyl CoA into malonyl coA (Bonner, 1956). Additionally sulphur increases protein content by providing disulphide group for cross linkage of two polypeptide chains in protein formation (Allaway and Thompson, 1966).

An analysis of yield data for net returns elucidated that sulphur at 45 kg ha^{-1} resulted in an extra returns of Rs. 2,213 ha^{-1}. But it was slightly higher compared to sulphur at 30 kg ha^{-1} (Rs.2181). Hence application of sulphur at 30 kg ha^{-1} seems to be economical.

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Table 1. Effect of sulphur and benzyladenine on drymatter production ($g\ m^{-2}$) of sunflower.

Treatments	Days after sowing 15		30		45		60		75	
	92	93	92	93	92	93	92	93	92	93
Sulphur ($kg\ ha^{-1}$)										
0	2.7	3.0	27.1	30.1	174.6	186.8	293.7	313.8	344.5	366.7
15	3.9	4.0	35.7	38.8	195.4	208.0	321.0	341.3	373.7	397.0
30	5.1	5.3	49.5	51.7	272.0	284.2	400.6	420.6	437.6	459.9
45	5.1	5.3	49.0	51.5	279.3	293.4	410.6	430.5	447.4	468.5
Benzyladenine (ppm)										
0					202.0	218.4	304.8	328.4	342.4	368.2
20					231.2	239.8	355.1	367.3	394.3	411.4
40					243.2	254.3	376.9	394.9	427.2	447.4
60					243.9	259.7	389.0	415.4	439.1	465.3
CD (0.05)										
S/S	NS	NS	0.9	1.6	7.2	9.2	11.8	16.1	18.7	20.4
SxB					NS	NS	NS	NS	NS	NS

Table 2. Effect of sulphur and benzyladenine on leaf area duration and chlorophyll index in sunflower.

Treatments	Leaf area duration (dm^{-2} $Plant^{-1}$ $weeks^{-2}$) Days after sowing 30-44		45-59		60-75		Chlorophyll index ($mg\ m^{-2}$) Days after sowing 45		60		75	
	92	93	92	93	92	93	92	93	92	93	92	93
Sulphur ($kg\ ha^{-1}$)												
0	163	176	212	227	141	150	600	629	423	446	135	143
15	174	187	222	236	149	157	698	727	461	483	153	160
30	239	249	282	295	174	182	1074	1098	595	614	209	216
45	247	259	297	312	182	190	1150	1190	652	669	236	243
Benzyladenine (ppm)												
0	175	188	204	219	128	147	590	625	310	330	94	103
20	202	210	252	261	160	166	898	913	537	548	190	196
40	223	234	276	288	175	183	1010	1035	625	646	222	228
60	224	239	282	301	181	192	1025	1070	658	687	226	236
CD(0.05)												
S/B	3.0	9.0	9.2	8.4	7.0	6.3	12.3	15.0	8.9	20.1	5.4	10.3
SxB	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Effect of sulphur and benzyladenine on yield components, yield and quality of sunflower

Treatments	No. of filled seeds per plant		No.of unfilled seeds		Filling percentage		Test Weight (g)		Yield (kg ha-1)		Protein content(%)		Oil content (%)	
	92	93	92	93	92	93	92	93	92	93	92	93	92	93
Sulphur (kg ha^{-1})														
0	360	376	122	130	74.6	74.3	43.6	44.0	1-73	1100	14.4	14.2	36.8	37.0
15	384	404	120	129	75.9	75.6	45.6	46.5	1185	1222	14.7	14.6	37.8	38.6
30	436	449	104	105	80.6	80.9	48.1	48.5	1339	1384	15.1	15.0	38.5	39.2
45	444	461	101	103	81.5	81.7	48.5	49.0	1365	1415	15.3	15.2	39.1	40.2
Benzyladenine (ppm)														
0	363	381	121	132	74.9	74.3	43.9	44.9	1097	1121	14.8	14.7	30.0	38.5
20	390	408	115	117	77.1	77.6	45.7	46.6	1204	1234	14.8	14.7	38.1	38.7
40	431	445	108	110	79.7	80.1	47.7	47.8	1317	1370	15.0	14.8	38.1	38.8
60	440	456	104	108	80.9	80.7	48.4	48.7	1343	1396	15.0	14.9	38.2	38.8
CD (0.05)														
S/B	12.8	15.3	2.6	2.1	1.6	1.7	1.3	1.3	32	59	0.36	0.12	1.01	1.15
SxB	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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SCREENING OF SAFFLOWER (*Carthamus tinctorius*) CULTIVARS FOR SALT TOLERANCE.

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ABSTRACT

A field experiment was conducted during rabi 1995 on a saline vertisol (1 to 20 ds m^{-1}) at ARS, Gangavathi to screen sixteen safflower genotypes for salt tolerance. The yield of safflower genotypes was correlated with time-weighted mean salinity to compute yield maxima (Ym), threshold salinity (ECt) and slope (S). Bhima, A-1, K-1, and Nira performed better than other genotypes. The performance of Bhima wa superior to K-1 and A-1 as salinity increased from 1.0 to 12 ds m^{-1}. The genotype, sharada which was promising under marginally saline conditions suffered at higher salinity (beyond 8 ds m^{-1}). Some growth parameters, Na/K accumulation and germination data also confirmed the above findings.

Key words : *Vertisol, salinity, safflower genotypes*

INTRODUCTION

Safflower is one of the most intensively investigated oilseed crop for relative salt-tolerance potential under different situations of saline soils, saline waters, or alkaline conditions. Though safflower is reported to be highly salt-tolerant (Weiss, 1971), the genotypic variations have been reported by Francois and Bernstein (1964), Janardhan *et al.* (1986), Gururaja Rao *et al.*, (1987) and more recently by Patil *et al.* (1992) in vertisols of Karnataka. The data generated on screening of genotypes for salt-tolerance on artificially salinised soils do not simulate the natural saline environment and are unrealistic. The present research work was carried out to evaluate the genotypic variations of safflower for salt-tolerance following Van Genuchten (1983) equation in a soil with a natural salinity gradient that exists on a slopy land.

MATERIALS AND METHODS

Sixteen safflower (*Carthamus tinctorius*) genotypes (Table 1) were sown during rabi 1995-96 in a vertisol at ARS, Gangavati with natural salinity gradient ranging from 1 to 20 dsm^{-1}. The land was divided into 16 blocks measuring 6m in length. Each genotype was sown in a line and in all the salinity blocks with a spacing of 60x30cm. 18 Kg urea, 50 kg single super phosphate and 7.2 kg of muriate potash were applied prior to sowing. All the genotypes received similar type of package of practices.

Soil salinity (0-30 cm depth) of each plot was estimated in alternate rows at 0, 40 and 110 days after sowing to compute time weighted mean salinity for each salinity block and related to its respective yield using piece-wise linear regression function as proposed by Van Genuchten (1983). Accordingly, 'Ym' 'ECt' and 'S' were calculated for each genotype. Based on these parameters, estimated yield levels of all genotypes at fixed salinity levels were calculated (Table 3) for the purpose of evaluation of genotypes.

Plant samples collected at 110 days after sowing were dried at 70°C - 80°C in an oven and finely ground in a wiley mill. Na^+ and K^+ content in root and shoot samples were determined in wet ashed extract using flame photometer. The yield and other growth parameters (Plant height, number of capsules, test weight, oil content) were also recorded.

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RESULTS AND DISCUSSION

Germination

In general, germination percentage declined in all the genotypes with an increase in salinity (Table 1). However, there was an improvement in germination with time except in case of HUS-305, T-65, Manjira and A-1. The genotypes Nira, JSF-1 recorded relatively larger percentage at all salinity levels as compared to other genotypes while in case of CO-1, JSI-7, germination increased progressively with time and salinity level as well. The highest germination of 71% was recorded by JSF-1 at 13 ds m^{-1} but at increased level of salinity (20.0 ds m^{-1}) it recorded only 52% germination and 33 and 51% in Bhima and CO-1 respectively. Patil *et al.*, (1992) observed similar effects on germination in safflower crop.

Growth and yield parameters

The data on plant height, number of capitula, plant stand and seed oil content were recorded for all the genotypes (Fig 1). When the salinity level was more than 4 ds m^{-1} HUS-305 recorded maximum pant height (74.5 cm) and lowest (55.3 cm) was in JSI-7. The plant height was also found to decrease in all genotypes with increase in salinity (Fig 1).

The number of capitula per plant decreased with an increase in salinity in most of the genotypes tested. However, genotype T-65 recorded higher number of capitula per plant than A-1 and Bhima at a salinity level of 8 ds m^{-1}.

Seed oil content was also found to decrease with an increase in salinity in many of the genotypes tested. When the salinity was less than 4 ds m^{-1}, highest oil content of 24.5 and 24.1 was recorded in K-1 and A-1 respectively. When the salinity level was more than 8 ds m^{-1}, APRR-3 recorded the maximum (22.1) while the lowest (12.1) was in JSF-1. Bhima and K-1 also recorded fairly higher oil content.

Plant stand per 6m row was also recorded. The maximum plant stand (15.5)was recorded by genotype Nira in salinity range less than 4 ds m^{-1} and that of lowest (10) was in Tara (Fig 1). When the salinity level was more than 8 ds m^{-1}, Bhima recorded maximum plant stand (11.3) with lowest (5) in Tara and A-300. The plant population in general, was found to decrease in all genotypes with an increase in salinity (Fig 1).

Elemental analysis

Table 2. Na/K ratio of various safflower genotypes in plant shoot as affected by salinity

Genotype	Salinity levels <2 ds m^{-1}	4-8 ds m^{-1}	
JSF-1	0.84	1.87	(+122.6)
HUS-305	0.81	1.43	(+76.5)
T-65	1.02	1.41	(+38.3)
N-7	0.76	1.07	(+40.8)
N-62-8	0.74	2.67	(+260.8)
A-300	0.57	1.01	(+77.2)
SHARADA	1.00	0.54	(-46.0)
CO-1	0.29	0.14	(-51.7)
BHIMA	0.38	0.04	(-89.5)
APRR-3	0.60	0.45	(-25.0)
A-1	0.25	0.14	(-44.0)
JSI-7	0.63	0.70	(+11.1)
Mean	0.60	0.96	(+45.4)

Figures in paranthesis indicate percentage increase or decrease over lower range.

The Na/K ratio of shoot (Table 2) increased with salinity in genotypes like HUS-305, N-7, N-62-8, A-300, JSI-7 whereas a reverse trend was observed in Bhima, A-1, CO-1, Sharada etc. Increased uptake of Na over K as evidenced by higher Na/K ratio made HUS-305, A-300, T-65, N-7, JSI-7 more susceptible to salinity. In case of A-1, Bhima, CO-1 and Sharada the decrease in the Na/K ratio was higher than APRR-3. This explains the possible selective ion exclusion mechanism that operates in case of A-1, Bhima, CO-1, Sharada where K is compensated for Na, thus reducing the Na/K ratios. From these results, it was quite evident that Bhima, A-1, Sharada, CO-1 were selectively more tolerant to soil salinity. Sharma (1989) attributed susceptibility of certain wheat and rice genotypes to the increased Na/K ratios.

Van Genuchten parameters

Quantitative parameters (Table 3) evolved by Van Genuchten (1983) were computed for all the genotypes to screen them for salt tolerance. An ideal genotype would be one with high yield maxima (Ym), high threshold salinity value (ECt.) and lower slope. But, in nature, it is difficult to find a genotype combined with all these quantitative characters. Out of 16 genotypes used in the study, Bhima, K-1, A-1 and Nira performed well in the entire salinity range from 2 to 12 ds m^{-1}. The varieties had relatively higher yield maxima, higher threshold salinity and lower slope as compared to other varieties. The genotype Bhima ranked first in its overall performance in addition to higher yield maxima than others, because of better performance at higher salinity (Beyond 10 ds m^{-1}) and higher threshold value (Table 3). The genotypes CO-1, Bhima, Sharada and Nira also recorded good germination and lower Na/K ratios in the root samples contributing to salt toleance. The varieties HUS-305, T-65, N-7, JSI-7, N-62-8 performed very poorly and were found unsuitable for cultivation under saline conditions even as evidenced by higher Na/K ratio at higher salinity. Thus it has been found that the varieties Bhima and A-1 outyielded all other varieties at all salinity levels. Tara was found to be salt tolerant and can be useful to the breeders in their breeding programme, though it is a low yielder.

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Table 1 : Effect of salinity on germination of safflower genotypes

	ECe (dSm⁻¹)																
	1.6				3.5				13.0				20.0				
Genotyp DAS	11	17	19	Mean	11	17	19	Mean	11	17	19	Mean	11	17	19	Mean	%*
Tara	61	61	64	62	48	50	52	51	32	39	42	38	24	24	31	25	60
Nira	90	95	97	94	75	78	78	77	53	70	71	65	54	59	63	59	37
JSF-1	94	94	94	94	78	78	78	78	58	75	79	71	47	51	57	52	45
HUS-305	67	67	69	67	57	57	57	57	44	57	57	53	32	35	45	37	45
T-65	76	76	76	76	69	69	69	69	55	59	59	58	43	47	54	48	37
Manjira	48	51	51	50	42	42	42	42	24	24	37	37	33	30	40	43	38
N-7	73	72	73	73	58	61	61	60	54	56	57	56	35	45	51	44	40
N62-8	48	49	49	49	49	50	50	50	33	38	40	37	29	29	30	29	41
A-300	48	49	49	49	49	50	50	50	33	38	40	37	29	29	30	29	41
Sharada	83	88	89	87	67	72	72	70	68	65	66	66	68	73	81	74	15
CO-1	60	59	61	60	53	55	55	55	63	68	70	67	47	51	55	51	15
Bhima	71	74	74	73	72	75	75	74	65	72	75	71	28	33	39	33	55
K-1	48	52	52	51	55	57	57	57	46	54	59	53	19	13	17	16	69
APRR3	59	61	61	60	59	58	58	58	47	43	44	45	15	24	29	23	62
A-1	61	64	64	63	63	74	74	70	55	60	60	58	26	31	40	32	49
JSI-7	63	65	66	65	61	66	67	65	50	58	58	55	37	55	60	51	22
Mean	66	68	69	68	60	62	63	62	49	57	58	55	36	40	46	41	-

DAS : *Days after sowing.* ECe : Electrical conductivity of saturated extract.
* Reduction in germination.

Table 3. Maximum yield, threshold salinity, yield reduction rate and estimated yields of safflower genotypes under saline conditions.

Genotype	Ym (g/plant)	Ect (ds m^{-1})	Slope (g/dsm^{-1})	Estimated yield (g/plant) at ECe (ds m^{-1}) 6	8	10	12
Tara	6.95	3.51	-0.08	5.65	4.60	3.55	3.32
Nira	29.26	3.19	-0.10	21.31	15.64	9.98	4.32
JSF-1	15.65	2.77	-0.08	11.36	8.70	6.04	3.38
HUS-305	10.53	3.21	-0.08	8.05	6.28	4.51	2.74
T-65	13.49	2.76	-0.08	9.93	67.74	5.55	3.36
Manjira	16.09	3.04	-0.09	11.83	8.96	6.08	3.21
N-7	11.78	2.93	-0.08	8.76	6.68	4.83	2.86
N-62-8	14.61	2.91	-0.09	10.71	8.18	5.66	3.13
A-300	14.81	3.07	-0.09	10.94	8.30	5.66	3.02
Sharada	24.82	3.57	-0.11	18.45	13.21	7.97	2.75
CO-1	17.30	3.07	-0.09	12.80	9.73	6.65	3.58
Bhima	36.91	3.31	-0.10	27.47	20.44	13.41	6.38
K-1	31.44	3.36	-0.09	23.74	17.91	12.08	6.25
APRR-3	22.95	3.47	-0.10	17.36	12.94	8.53	4.11
A-1	34.27	3.68	-0.10	27.00	19.88	12.76	5.64
JSI-7	11.71	3.08	-0.09	8.59	6.46	4.32	2.19

Ym = Maximum yield under normal conditions.
ECt = Threshold salinity.
ECe = Electrical conductivity of saturated extract of soil.

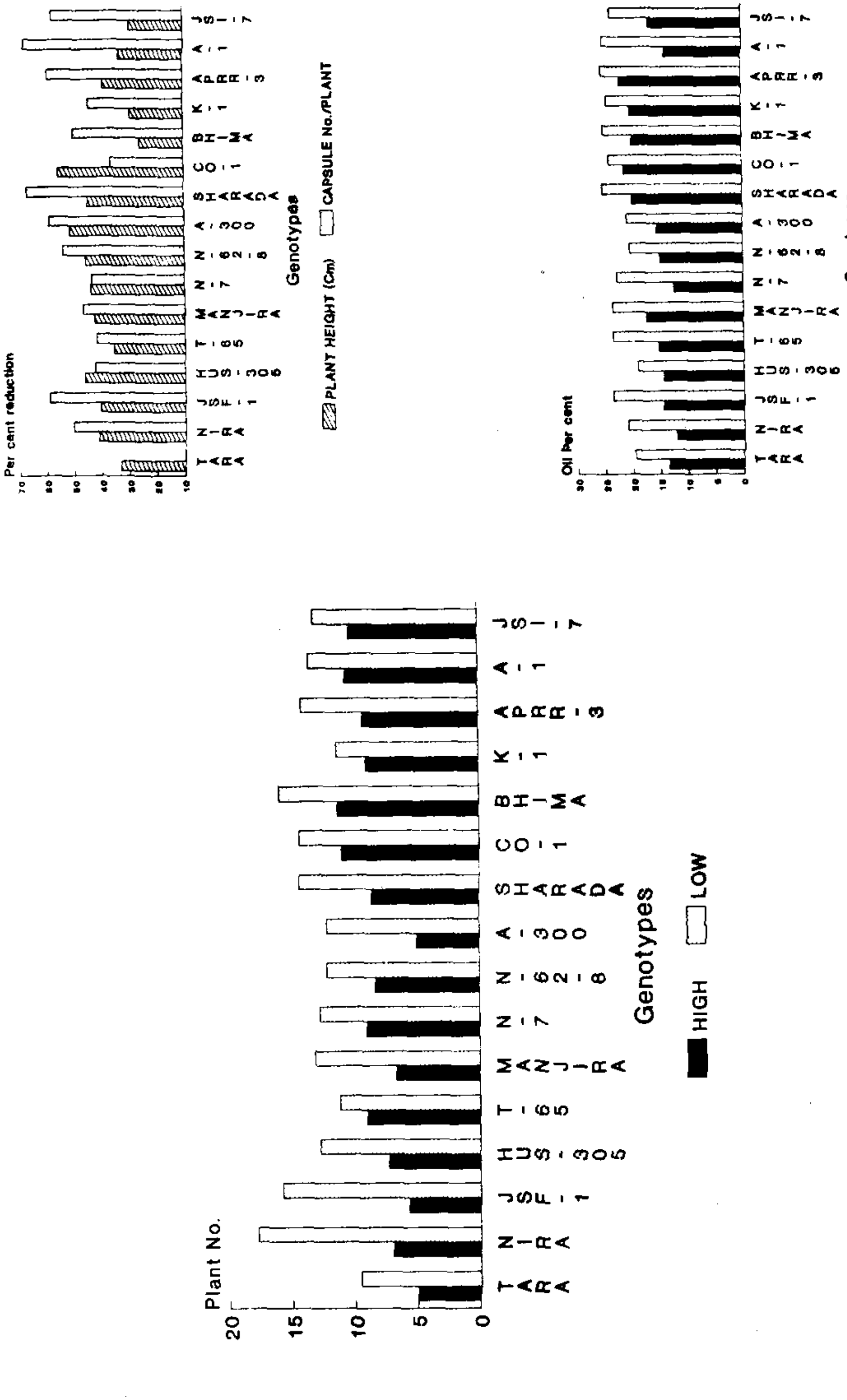

Fig - 1 : Salinity effect on growth parameters of Safflower Genotypes

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PEST SCENERIO OF SAFFLOWER IN THE DRY TRACT OF KARNATAKA

Safflower (*Carthamus tinctorius* L.) is an important Rabi oilseed crop and India is the largest producer of safflower in the world. The crop is raised over an area of 7.7 lakh hectares with a production of 4.2 lakh tonnes and a low productivity of 543 kg/ha (Anon., 1995). Karanataka state is the second largest producer of safflower in the country. Among several reasons for such low per hectare yields, insect pests contribute a major share for yield loss in safflower.

Narayanan (1961) has recorded safflower fly, a few caterpillar pests and a species of aphid as serious pest among many insect pests that infest safflower crop. Many workers have reported the species of aphid as a major pest among several insect pests that cause damage to the crop (Rai, 1976; Anon., 1984). As high as 79 different insect species have been reported feeding on safflower (Basavanagouda, 1979) and many of them are known to cause severe damage to safflower crop in several parts of the world. The safflower aphid, *Uroleucon compositae* under favourable conditions may cause yield loss upto 72 percent (Basavanagouda, 1979). Parlekar (1987) has enlisted about 36 insect pests on safflower in Maharashtra state. However, in recent years, the minor pests like capsule borer and leaf miner are attaining a major status causing heavy damage to the crop.

Field survey was carried out for ten years (from 1987 to 1997) in the northern dry tract of Karnataka comprising of six major safflower growing districts. The roving survey was made once in a crop growth period preferably during flowering stage. In each district, seven to eight spots were surveyed and average of all the places was computed. The data on the incidence of various insect pests is presented with the help of the following index.

Survey made over a number of years indicated that a total of 20 insect pests were found feeding on safflower, These inturn have been harboured by about 9 different species of natural enemies (Table 1). Most of these insect pests have already been recorded as pests of safflower in various parts of the country. However, in Karnataka many of the enlisted pests and their natural enemies are new records on safflower crop.

Only the pests and natural enemies which have consistent appearance over years have been included (Table 2). Aphids, capsule borer and safflower caterpillar have been noticed for all the ten years of survey, while the remaining pests were

Category	No. of aphids/5cm apical twig/pl.	Percent infestation of other insects	Classification
Low	Less than 25	1 to 10	Minor pest
Moderate	26 to 50	11 to 30	Moderate pest
High	51 to 75	31 to 50	Major pest
Very high	More than 75	51 to 100	Major pest

For the natural enemies, only their presence of absence was considered.

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not of regular occurence. By and large, aphid infestation varied from high to very high in different years of survey causing severe loss to the crop. Though the incidence of capsule borer was of moderate intensity for many years, due to its intensive feeding on economic plant parts, it was found capable of causing extensive damage to the crop. However, the remaining pests did not cause considerable damage to the crop owing to their irregular occurence and low density of population. The total loss to the crop by these pests was minimum or negligible in some cases.

Among the natural enemies, coccinellids and chrysopids were regularly noticed for all the ten years of survey. Both these predators were found feeding voraciously on the aphids indicating their potentiality as effective bioagents for aphid control. Only one parasitoid i.e., *Pseudendaphis* sp. has been recorded parasitising on aphids. Whereas, the remaining parasitoids (Dipterans and Hymenopterans) were recorded as parasitoids of lepidopteran insect pests. Syrphids were observed predating on small sucking insects while preying mantids as general predators, even found feeding on early instars of lepidopterans.

Though several authors in the country as well as abroad have recorded these insect species as pests of safflower, such work in Karnataka State is limited. And hence, many of these insect pests and their natural enemies have been recorded for the first time in the state.

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Table 1 . Pests of safflower and their natural enemies

Sl.No.	Common name	Scientific name	Remarks
	Insect pests		
1.	Safflower aphid	*Uroleucon compositae* (Theobald)	Major pest
2.	Capsule borer	*Helicoverpa armigera* (Hubner)	Major pest
3.	Safflower caterpillar	*Perigia capensis* (Walker)	Minor pest
4.	Green semilooper	*Plusia Orichalcea* (Fab.)	Minor pest
5.	Leafminer	*Phytomyza atricornis* (Maig)	Minor pest
6.	Stemfly	*Melanagromyza* spp.	Negligible pest
7.	Podfly	*Acanthophilus helianthi*	-do-
8.	Stem borer	*Eublemma rivula* (Moore)	-do-
9.	Surface Grasshopper	*Chrotogonus* spp.	-do-
10.	Lucerne caterpillar	*Spodoptera exigua* (Hub.)	Minor pest
11.	Thrips	-	-do-
12.	Jassids	-	-do-
13.	Whitegrub	*Holotrichia serrate* (Fab.)	Negligible pest
14.	Plantbugs	*Nezara viridula* Distant *Dolycoris indicus* Stol.	-do-
15.	Cutworms	*Agrotis* spp.	-do-
16.	Wireworm	*Agriotes* spp.	-do-
17.	White flies	-	-do-
18.	White ants	*Termes* spp.	-do-
19.	Pyrilla	*Pyrilla* spp.	-do-
20.	Crickets	-	-do-

Natural enemies

	Name	Host
1.	Coccinellids	Predators on aphids and other sucking insects
2.	*Chrysopa* sp.	-do-
3.	*Rogas percurrens* (Iyle)	Parasitoid of lepidopterous caterpillars
4.	*Apanteles ruficrus* (Hal.)	-do-
5.	*Campoletis chloridae* (Uch.)	-do-
6.	Tachinids	-do-
7.	Syrphids	Predators on aphids and other small insects
8.	*Pseudendaphis* sp.	Parasitoid of aphid
9.	Preying mantids	General predator including small caterpillars

Table 2. Incidence of safflower pests and their natural enemies.

Sl No	Name of the pest/Natural enemy	1987 88	1988 89	1989 90	1990 91	1991 92	1992 93	1993 94	1994 95	1995 96	1996 97
	I. PESTS										
1.	Aphids	Very high	Very high	Mod.	Mod.	Mod.	High	High	High	Mod.	Very high
2.	Capsule borer	Mod.	Mod.	Low	Mod.	Low	Mod.	Mod.	Low	Low	Mod.
3.	Safflower caterpillar	Low	Low	Low	Low	Low	Mod.	Mod.	Low	Low	Mod.
4.	Leaf miner	Low	Low	Low	-	-	Low	Low	Low	Low	Low
5.	Stemfly	Low	Low	-	Low	-	-	-	-	-	Low
6.	Semilooper	Low	-	-	-	-	-	-	-	Mod.	Low
7.	Thrips	Low	Low	Low	-	-	-	-	-	Low	Low
8.	Jassids	Low	Low	Low	-	-	Low	Low	Low	Low	Low
9.	Lucerne caterpillar	Low	-	-	-	-	-	Low	Low	Low	Low
	II. NATURAL ENEMIES										
1.	Coccinellids	P	P	P	P	P	P	P	P	P	P
2.	Chrysoperla	P	P	P	P	P	P	P	P	P	P
3.	Apanteles	P	P	P	P	P	-	P	P	P	P
4.	Tachinids	P	P	P	-	P	-	-	-	P	P
5.	Syrphids	P	P	P	P	P	P	-	-	-	P
6.	Pseudendaphis	P	P	-	-	-	P	-	-	P	P

P = Present

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PRIMARY TILLEGE IN RELATION TO IRON STRESS OF RAINFED GROUNDNUT IN ALFISOLS.

Groundnut is the major oil seed crop grown in scarce rainfall zone of Andhra Pradesh. For raising this crop, performing primary tillage with the on-set of summer rains is a common practice, for which various implements are used depending on moisture availability. An experiment conducted at Anantapur on Alfisols with different tillage methods to control weeds in groundnut showed chlorosis in certain treatments even after weeds were controlled due to variations in root growth (Anonymous, 1988). The nature of seasonal chlorosis investigated by phaneendra Bhaskar (1990) showed that there were fluctuations in active Fe content corresponding to moisture availability in the soil profile with appearance of chlorosis whenever moisture stress is mitigated following rains. The present investigation was carried out to study the effect of primary tillage one nature of chlorosis.

Field experiment was conducted in RBD with four replications at Agricultural Research Station (Dryland Farming), Anantapur, Andhra Pradesh during Kharif 1992 to evaluate the influence of primary tillage using various implements on extent of chlorosis as determined by the active iron and chlorophyll contents in rainfed groundnut on Alfisols. The soil was sandyloam in texture with bulkdensity 1.57 g cc^{-1}, nearly neutral (pH 6.68), non-saline (0.089 dSm^{-1}) medium in organic carbon (0.35%), available phosphorus (17.9 kg ha^{-1}) and available Potassium (185 kg K ha^{-1}). The DTPA extractable micronutrients in ppm were, Zn 0.72, Cu 0.92, Fe 9.16 and Mn 13.0.

Primary tillage was carried out once using animal drawn implements like Blade harrow (T1), chekkala guntaka (T2) (a wooden implement with three tynes, opens furrow of 30 cm apart to a depth of 7 to 8 cm), wooden country plough (T3) tractor drawn tiller (T4) and chisel plough (T5) and were compared with no-primary tillage treatment (control, T6). Primary tillage operation was done with receipt of first summer showers except in T6. However all other cultural operations from sowing to harvest of crop were the same under all treatments.

Groundnut crop (T MV - 2) was sown on 9-7-92 with receipt of sufficient rains using a bullock drawn seed cum fertilizer drill. Recommended dose of NPK (20:17:33 kg ha^{-1}) was applied as basal through urea, DAP and muriate of potash.

Leaf samples (3rd & 4th leaf from top) were collected at 19 and 33 DAS from all the treatments from two replications to estimate active iron (Katyal and Sharma, 1980) and chlorophyll content (pettering *et al*, 1940) and the results were expressed in ppm and mg g^{-1} on oven dry basis, respectively. The relationship between these two parameters was worked out, while the drymatter and yield were computed from the data of four replications.

The plant chlorophyll and active iron contents observed at 19 DAS varried from 4.70 (T2) to 5.45 mg g^{-1} (T5) and from 40.0 (T2) to 58.5 ppm (T4), respectively (Table 1). At (33 DAS) the values for chlorophyll content ranged between 4.91 (T3) and 5.70 mg g^{-1} (T6) and active iron content ranged between 45.0 (T2) and 66.0 ppm (T4). Low values of chlorophyll and active iron were observed in T2 and T3 both at 19 and 33 DAS leading to the observed slight chlorosis.

This chlorosis was associated with low active iron content and was not induced due to imbalance of nutriets, as the soil micro and macro nutrients are above the critical limits and the advantage of primary tillage on crop performance was established earlier. It was observed that under

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country plough (T3) & chekkalaguntaka treatments, (T2) thus was a passing phase of iron chlorosis, since these treatments had benefical effects on soil moisture availability (Fig.1) leading to higher drymatter and yield (Table 1). Active iron content of leaf showed that chlorosis was due to temporary lowering of active Fe content. The active iron (Y) and chlorophyll content (X) were significantly correlated confirming the Fe stress and could be expressed by the equation :

$$Y= 22.07x - 64.6789 \ (r= 0.869).$$

Phaneendra Bhaskar (1990) found that in rainfed groundnut in Alfisols, chlorophyll content of less than 4.5 mg g^{-1} and active iron content of less than 40.0 ppm were associated with visible iron chlorosis. The present results confirm the earlier findings. Chlorosis was observed in T2 & T3 although the values were slightly higher with respect to active Fe at 33 DAS than earlier report. The presence of low chlorophyll and active iron contents in these treatments during early growth periods did not effect the yield as these primary tillage operations brought out benefical effects on soil by way of better soil moisture storage leading to "Dilution effect" of this element. Such dilution effect with respect to iron was demonstrated in grape vines by Haussling *et al* (1985).

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Table 1 : Effect of primary tillage on chlorophyll, active iron, drymatter and yield of rainfed groundnut in alfisols.

Treatment	Chlorophyll (mg g^{-1})		Active Fe (ppm)		Drymatter yield (g.pl-1)		Pod Yield (kg ha-1)
	19 DAS	33 DAS	19 DAS	33 DAS	25 DAS	40 DAS	
T1 Blade harrow	5.30	5.55	50.5	55.5	0.61	3.94	1453
T2 Chekkalaguntaka	4.70*	5.00*	40.0	45.0	0.83	5.00	1688
T3 Country plough	4.80*	4.91*	40.6	47.5	0.95	4.75	1576
T4 Tiller	5.25	5.40	58.5	66.0	0.83	3.90	1469
T5 Chisel plough	5.46	5.50	57.0	62.0	0.74	4.48	1366
T6 No Primary tillage	5.35	5.70	47.5	50.5	0.34	2.72	1120
CD (0.05)					0.11	0.30	177

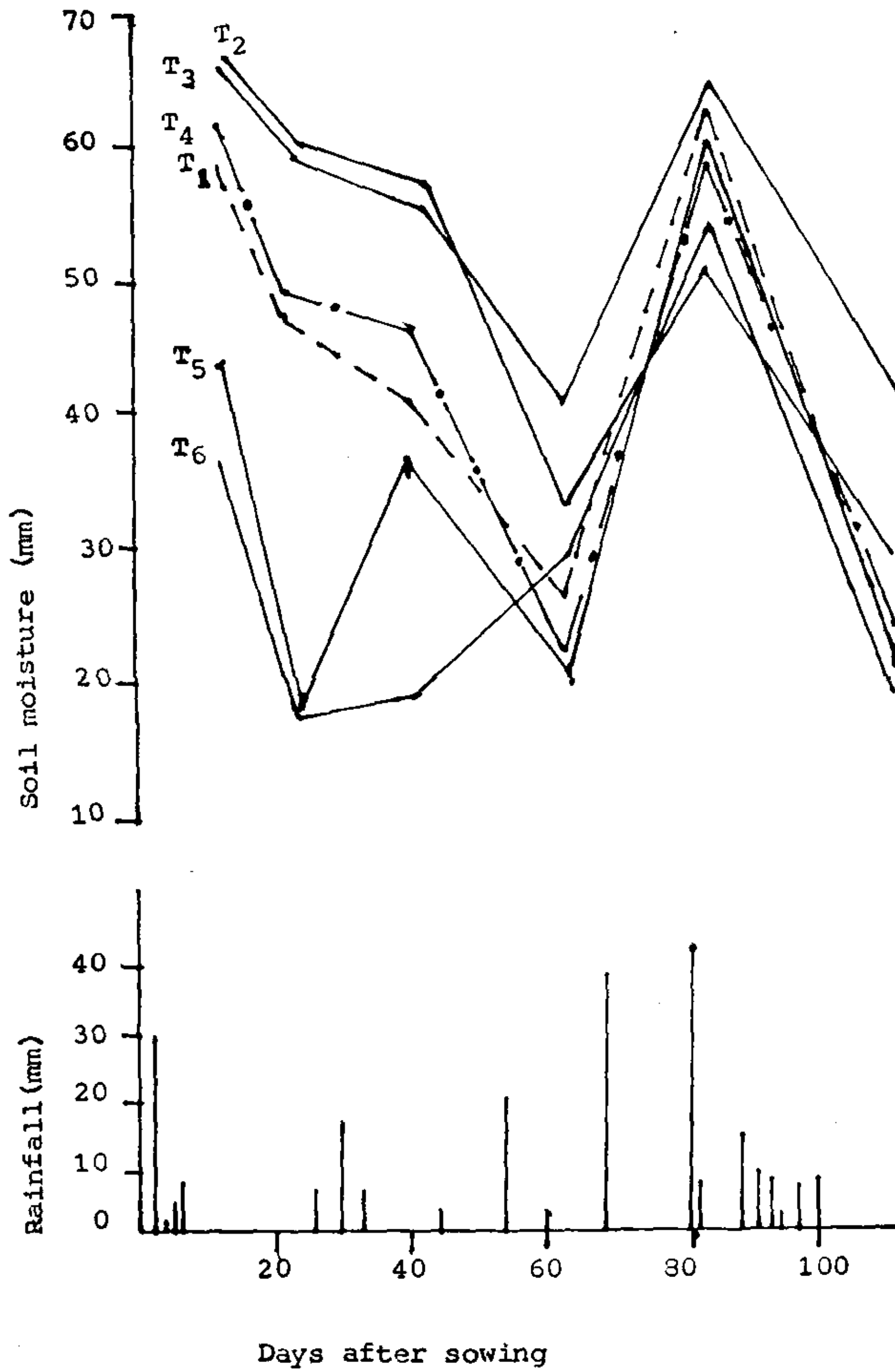

Fig- 1: Soil moisture (0-30 cm depth) as influenced by Primary tillage methods.

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INFLUENCE OF SOIL PROPERTIES ON GROWTH AND YIELD OF GROUNDNUT IN SWELL-SHRINK SOILS.

Groundnut is one of the major crops grown on the swell shrink (black) soils of India. Its growth and yield varies depending on soil-site characteristics and hence this study was undertaken to relate the effect of soil-site parameters, and ultimately the soil taxonomic unit, on growth, maturity and yield of groundnut.

The detailed soil survey of a watershed in village Khapri (Barokar) in Katol taluka of Nagpur district in Maharashtra State was conducted. The soils were classified to series level according to USDA Soil Taxonomy (Soil Survey Staff, 1975). The soil samples were analysed for texture, plant available water holding capacity (PAWC) (Coughlan *et al.*, 1986), organic carbon, and calcium carbonate contents (Table 1). During *Kharif* 1991 and 1992, the amount of rainfall received was 670 and 437 mm in 51 and 30 rainy days, respectively. Effective rainfall was calculated for the groundnut cropping seasons by subtracting the water surplus from the total rainfall after meeting the crop evapotranspiration and water storage capacity of each soil series under study. Crop evapotranspiration and water surplus were calculated using Thornthwite Water Balance coucept as described by Rao *et al.* (1976).

The field experiments carried out during *Kharif* 1991 and 1992 consisted of seven soil series as main plots and two levels of integrated inputs management (Low and Optimum) as subplot treatments in a split-plot design with three replications. The plots with low management received 9 Kg N and 23 Kg P_2O_5 (i.e. 50 Kg Diammonium Phosphate (DAP)) per ha at sowing, one hoeing at 30 days after sowing (DAS) and one earthing at 45 DAS as per the farmers practice of this region. Wherease, the plots with optimum management received *rhizobium* seed treatment, 20 Kg N and 50 Kg P_2O_5 per ha with N in two splits (10 Kg N at sowing and the remaining 10 Kg N at 30 DAS) and the entire P_2O_5 as basal, two hoeings (15 and 30 DAS), one weeding (at 30 DAS), one earthing-up (at 45 DAS) and adequate plant protection measures. Single Super Phosphate (SSP) which also contains calcium and sulphur was used as phosphorus source and urea as nitrogen source to the crop. The growth attributes of groundnut viz., leaf area duration (LAD), maximum tap root length, root and shoot dry matter (DM) accumulation and number of filled pods per plant were studied from three random samples taken during different plant growth phases. Number of days taken from sowing to harvest was recorded as maturity duration of the crop and the pod yield per ha was calculated from the pod weight per plot ($12m^2$) recorded in each treatment.

At the soil suborder level, groundnut generally yeilded high on Typic/Vertic Ustochrept and Typic Chromustert during both the years, wherease it fared well on Lithic and Typic Ustorthents only in 1991, a well distributed rainfall year. At series level, that is on Khapri-3(a), 7, 8 and 5 groundnut on an average yielded in the range of 12.82 to 13.25 q per ha Khapri-3(b) (11.45 q/ha) and Khapri-4 (8.99 q/ha in 1991). The growth and yield parameters viz., LAD, maximum root length, root-shoot DM and number of pods per plant (Table 1) showed similar trend as the pod yield. Maximum root length recorded at physiological maturity stage showed nonsignificant differences among soil series in the first year, thus indicating its poor response to soil depth when soil moisture was optimum. Whereas, in the second year the deep Khapri-5 recorded the highest root length (28.2) which was significantly higher than that observed in all other

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soil series. Khapri-2(b) having a very shallow soil depth, had a root length of only 15.7 cm. Similarly, the crop matured late on Khapri-5, 7 and 8 which had deeper soil depth and higher PAWC. However, the maturity duration had little effect in increasing the pod yeild of groundnut but remarkably increased LAD and root-shoot DM production.

From the observed quadratic relationship between PAWC and mean pod yield (Y=0.00027X2+0.0919X+5.95104), it is clear that with increase in PAWC, the crop responded linearly up to around 90 mm and thereafter it became non responsive. Thus a groundnut crop of 90 to 100 days duration need an optimum PAWC of 80-100 mm and hence Khapri-5 (Fine, montmorillonitic, Typic Chromustert) having a PAWC of 218 mm was in no way superior and on par with other Typic or Vertic Ustochrepts viz., Khapri-3(a), 7 and 8. Whereas, Khapri-1 and 2(b) (Loamy, mixed, Lithic Ustorthent) whose soil depths were very shallow (17 and 6 cm) and thereby could not harvest and store adequate rainwater to mitigate the unpredictable dryspells (PAWC of 17 to 24 mm) and thus recorded poor yields.

The above results show that among the soil-site characteristics, the major factor responsible for such differences in growth, duration and yield was moisture storage capacity in the solumn of each soil, that is the total PAWC. Soil depth and texture are the major characteristics for variation in total PAWC with deeper the soil and finer the texture, greater is the capacity of soil for water retention and supply to plants for better growth and yield (Gajbhiye *et al.*, 1988).

The total PAWC of soil directly influenced the effective rainfall although the total rainfall during a cropping season was the same on all the soil series. Khapri-2(b) having the lowest PAWC of 17 mm the effective rainfall was 296 and 277 mm in first and second seasons, respectively, wherease Khapri-5 having 218 mm of total PAWC could conserve the entire rainfall of 437 mm in first season and 497 out of 693 mm in the second season. Since effective rainfall is a product of actual rainfall, its distribution and storage capacity of the soil, establishing its relationship with pod yield showed that the pod yield increased up to 400 mm of effective rainfall and thereafter a slight declining trend (Y=-0.0002X2+0.1783X-25.8452) as it was the case in Khapri-5 particularly during the first year. Kapri-5 being a deep heavy soil located on the lower most plain of the watershed, the clay content up to 90 cm soil depth ranged from 59 to 75 per cent in different horizons and hence could store 497 mm of rainwater out of 678 mm during the 1991 *Kharif* season. This might have lead to improper aeration resulting in reduced root-shoot DM production, number of pods per plant and consequently the pod yield.

Among the other soil parameters, calcium carbonate ($CaCo_3$) content also affected the productivity of groundnut. The Typic Ustochrepts viz., Khapri-3(a) and 7, containing more than nine per cent $CaCo_3$ in the Ap horizon, recorded an average pod yield of around 13.2 q per ha. Khapri-3(b) a Lithic Ustorthent, also containing more than nine per cent $CaCo_3$ had an average yield of 11.4 q per ha and the response was more in *Kharif* 1991 when soil water was not limiting. Groundnut prefers a calcareous rooting media as it needs calcium for pod growth. Sehgal et al. (1988) also reported positive response of groundnut to lime content of up to 18 per cent. Similarly, the favourable impact of sand content on pod yield. was conspicuous particularly in *Kharif* 1991 during which well distributed rainfall brought no moisture stress for the crop. Among the Lithic/ Typic Ustorthents, Khapri-2(b) and 3(b) whose sand contents were 55 to 57 per cent fared better during *Kharif* 1991 as against Khapri-1 whose sand content was only 25 per cent in the Ap horizon. Similarly, a sand content of 34 to 42 per cent in Typic Ustochrepts viz., Khapri-3(a) and 7 might have been responsible for higher yield in *Kharif* 1991 (12.85 to 15.05 q/ha) over Khapri-4 (9.08 q/ha) whose sand content was only 23 per cent and had highest clay of 63 per cent in Ap horizon.

It is concluded from the above that total PAWC was the prominant factor among others influencing the growth and yield of groundnut. When the rainfall was enough and well distributed, other soil characteristics viz., $CaCo_3$ and sand contents were also favourable for groundnut growth along with total PAWC.

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Table 1: Soil-site characteristics and their influence on groundnut growth and yield

Land-form	Hori-zon	Depth (cm)	Sand (%)	Clay (%)	Org.C (%)	CaCO3 (%)	Tot. PAWC (mm)	Rff.rainfall (mm) 1991	1992	LAD (days) 1991	1992	Max. root length (cm) 1991	1992	Root+Shoot DM (g/plant) 1991	1992	No.of pods/ plant 1991	1992	Maturity duration (days) 1991	1992	Pod yield (g/ha) 1991	1992
ENTISOLS																					
1. Khapri-1, loamy, mixed, hvprthemic family of Lithic Vstorthent :																					
Upper	Ap	0-17	25.4	59.8	0.56	6.0	24	303	-	120	-	19.5	-	34.3	-	6.5	-	95	-	8.05	-
plain	Cr	17-33	-	-	-	-															
2. Khapri-2 (b), Loamy, mixed hyperthermic family of Lithic Ustorthen :																					
Escarp-	Ap	0-6	57.3	25.6	0.86	-	17	296	277	128	70	18.1	15.7	41.9	16.7	11.5	4.5	95	94	11.27	5.67
ment	Cr	6-15	-	-	-	-															
3. Khapri-3(b), Loamy, mixed (calcareous) hyperthemic family of Typic Ustorthent :																					
Upper	Ap	0-15	55.2	31.3	0.58	9.1	66	345	326	164	84	21.7	20.4	42.0	37.8	14.5	11.5	95	94	13.20	9.70
plain	Cr	15-50	57.3	27.2	0.34	9.8															
INCEPTISOLS																					
Upper	Ap	0-18	42.0	36.0	0.53	9.7	128	407	388	173	120	23.0	23.5	43.5	44.5	14.0	12.5	95	94	12.85	13.67
plain	Cr	18-39	38.0	39.5	0.43	29.9															
	B2k	39-50	50.9	29.5	0.35	32.0															
	Crk	50-120	-	-	-	-															
5. Khapri-4, Clavey, montomorillontic (calcareous) hyperthermic family of Typic Ustochrept:																					
Upper	Ap	0-15	22.8	63.4	0.53	6.1	86	365	346	125	87	20.6	19.3	35.9	34.8	9.0	10.0	95	94	0.08	8.90
plain	B	15-34	30.3	42.3	0.44	7.1															
	Cr	34-80	41.7	38.9	0.24	7.46															
6. Khapri-7, Clavey, montmorillonitic (calcareous) hyperthermic family of Typic Ustocherept:																					
Lower	Ap	0-15	34.2	52.1	1.13	9.2	80	359	340	211	106	22.5	21.4	55.9	44.8	17.5	11.5	106	99	15.05	11.33
plain	B1	15-23	31.5	43.3	0.81	6.9															
	B2	23-45	35.0	46.5	0.89	5.3															
	Cr	45-75	-	-	-	-															

Contd.....

Land-form	Hori-zon	Depth (cm)	Sand (%)	Clay (%)	Org.C (%)	CaCO3 (%)	Tot. PAWC (mm)	Rf. rainfall (mm) 1991	Rf. rainfall (mm) 1992	LAD (days) 1991	LAD (days) 1992	Max. root length (cm) 1991	Max. root length (cm) 1992	Root+Shoot DM (g/plant) 1991	Root+Shoot DM (g/plant) 1992	No.of pods/plant 1991	No.of pods/plant 1992	Maturity duration (days) 1991	Maturity duration (days) 1992	Pod yield (g/ha) 1991	Pod yield (g/ha) 1992
7. Khapri-8, Fine, montmorillonitic, hyperthermic, family of Vertic Ustoochrept :																					
Lower	Ap	0-14	13.8	56.2	1.05	0.9	90	-	350	-	118	-	23.3	-	51.0	-	14.0	-	99	-	12.82
plain	B2	14-29	13.3	60.2	0.89	1.3															
	B3k	29-51	31.8	48.2	0.62	16.2															
	Crk	51-66	-	-	-	-															
VERTISOL																					
8. Khapri-5, Fine, montmorillonitic, hyperthemic family oof Typic Chromustert:																					
Lower	A11	0-11	23-1	59.2	1.01	4.7	218	497	437	172	132	24.3	28.2	48.8	49.8	13.5	ı3.0	106	104	12.45	13.66
	A12	11-30	13.3	74.8	0.79	5.1															
	A14	56-90	16.9	75.3	0.35	5.3															
	AC	90-108	50.5	43.3	0.30	8.3															
	Cr	108-120+	-	-	-	-															
Mean								367	352	156	102	21.4	21.7	43.2	39.9	12.3	11.0	98	97	11.71	10.82
SEm±										11	9	1.5	1.4	3.1	2.8	2.0	2.1	0	0	0.69	0.95
C.D at 5%										34	28	NS	4.4	9.7	8.5	6.3	NS	0	0	2.13	2.94

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SEASONAL OCCURRENCE OF POD BORERS OF GROUNDNUT IN RED LATERITIC SOILS

In semi-arid tropics, whitegrub, termites, millipedes, wireworms and earwig bore holes on groundnut pods (Wightman and Amin, 1988), However, the earwig (*Euborellia stali*), false wire worm (*Penthicoides seriatoporus* Fair), wireworms (sp. unidentified), termites (*Odentotermes* sp) and blind ant (*Dorylus orientalis* West wood) were reported as major pod borers of groundnut in India. Pod borers are considered as serious pests since they cause direct economic loss (20-60%) by destroying the groundnut pods. In Tamil Nadu, earwig was the only pod borer recorded in South Arcot and Coimbatore districts (Cherian and Basheer, 1940), where groundnut is grown on sandy soils. So, the present investigation was undertaken to identify the various pod borers of groundnut, their nature and extent of damage and seasonal occurrence under red lateritic soils (alfisols) of Pudukkottai district of Tamil Nadu.

The study was carried out at National Pulses Research Centre, Vamban, Pudukkottai district of Tamil Nadu using the groundnut variety TMV 7 under irrigated conditions in red lateritic soils. Sowings were taken up at fortnightly intervals continuously for one year from August 1994 to July 1995. The crop was sown in $20m^2$ plots replicated three times with a spacing of 30 x 10 cm. All cultivation practices were imposed as suggested except the plant protection measures. The pod borers, their nature, nature of damage and extent of damage on the basis of per cent infested pods were assessed at the time of harvest. The dry pod yield was recorded after harvesting and proper drying.

The study revealed that wireworms (sp. unidentified)and blind ant *Dorylus* sp were found damaging groundnut pods besides the earwig. *Euborellia stali* (=*Anisolabis annulipes*). Earwigs were found to prefer young and developing pods, while wireworms preferred mostly matured pods. The bore holes due to earwig were mostly plugged inside with sand particles, decayed pulp and excreta. The infested pods were either empty or with partly fed kernels and rarely with sand and faecal materials. These results are in accordance with the report of Purushothaman *et al.*, (1970). The pods infested with wireworms had boreholes of different sizes either plugged or unplugged and pods were filled with faecal and decayed materials. On piercing, wireworms first tunnelled the pulp of the husk and then damaged the kernels. Since the damage caused by earwig and of wireworms could not be distinguished while taking observations, the per cent damaged pods due to these pests was assessed as total. The blind ant scraped the shell of matured pods and bored either spherical or round holes which were 3 to 5 mm in size more often at the beak or abdomen area of pods and fed on kernels. The infested pods were either empty or filled with sand particiles. Wightman and Ranga Rao (1993) described that blind ants make several neat, round holes of 0.5 to 2 m in dia. and remove the seed completely without leaving any soil inside the empty shell.

The earwigs and wireworms caused 1.2 to 11.5 per cent pod damage and noticed throughout the year. The earwig was the predominent borer which accounted for 80 to 90 per cent of the total damage. The per cent pod damage was high in crops sown during second fortnight (hereafter referred as FN) of January to first FN of March and first FN of June to first FN of February (11.49) followed by first fortnight of August (7.69). The damage was low on crops sown during other periods and there was no damage if sown during the second FN of April. This indicated that crops

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sown during Kharif (June-July), late kharif (August), and spring (Feb. - March) registered low pod damage. Barwal and Gupta (1991) reported that earwig incidence was high in crops sown during summer months (May - July). The attack due to the blind ant, a sporadic pest in groundnut, was severe on crops sown during the period December to April and its damage on pods ranged between 1.82 per cent in crops sown in first FN of May to 30.21 per cent in crops sown in first FN of February (Table 1), while pods were completely free from borer damage if sown during other periods.

When the total pod damage due to all the borers was considered, it was high in crops sown during December to April and August (7.02 to 35.63%), moderate during May to July (2.70 to 6.67) and low during the months of September to November (1.43 to 4.86). Thus the study indicated that adoption of control measures against pod borers in groundnut sown during the regular seasons was essential. The yield was maximum in crops sown during second FN of December (1440 kg/ha) and low if sown during second FN of September (570 kg/ha). Inspite of pod borer attack, higher yield was registered during winter (968-1440 kg/ha) followed by early spring (940-1005 kg/ha) and kharif (895-922 kg/ha) than other seasons. It calls for preventive measures against pod borers to avoid the yield loss during these seasons.

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Table 1. Seasonal occurrence of pod borers in groundnut.

Sowing Seasons	*Fortnight sowing*		*Pod damage (%) due to* Earwig & wireworms	Blind ant	Total	Pod Yield (kg/ha)
Late	August '94	I	7.69	0.0	7.69	630
Kharif		II	7.02	0.0	7.02	644
Non	September '94	I	4.86	0.0	4.86	625
sowing		II	1.74	0.0	1.74	570
season	October '94	I	2.48	0.0	2.48	580
		II	1.43	0.0	1.43	660
	November '94	I	2.23	0.0	2.23	700
		II	3.72	0.0	3.72	825
Late	December '94	I	2.15	26.60	28.75	1172
Rabi		II	2.96	23.08	26.05	1440
	January '95	I	2.03	7.54	9.57	1040
		II	4.32	6.89	11.21	968
Early	February '95	I	5.17	30.21	35.38	940
Summer		II	11.49	24.14	35.63	1005
	March '95	I	5.88	11.76	17.67	806
		II	1.22	12.04	13.26	785
Summer	April '95	I	2.57	20.47	22.98	878
		II	0.0	6.67	6.67	690
	May '95	I	2.32	1.82	4.14	870
		II	3.50	2.0	5.50	857
Kharif	June '95	I	4.55	0.0	4.55	922
		II	6.20	0.0	6.20	895
	July	I	2.70	0.0	2.70	908
		II	4.53	0.0	4.53	922
SEd			0.73	2.33	2.33	
CD (0.05)			1.52	4.84	4.83	

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GROWTH AND YIELD OF SUNFLOWER AS INFLUENCED BY IRRIGATION AND NITROGEN MANAGEMENT

To stabilize oilseed production, the productivity of oilseed crops has to be increased manyfolds. Cultivation of sunflower became very popular in the Southern Agroclimatic zone of Andhra Pradesh after groundnut. Irrigation and fertilization are the main inputs to increase the productivity of the crop apart from variety.

To study the response of sunflower crop to irrigation and nitrogen management, a field experiment was conducted during rabi 1994-95 on sandy clay loam soils of Tirupati (A.P.). Three levels of irrigation schedules based on IW/CPE ratios of 0.5, 0.75 and 1.0 with three levels of nitrogen at 0, 50 and 100 kg/ha were tested in a randomised block design replicated three times. The soil was medium in depth (60 cm) and neutral in reaction, low in organic carbon (0.26%), low in available nitrogen (170 kg/ha), high in available P_2O_5 (105 kg/ha) and medium in available K_2O (206 kg/ha). The field capacity, permanent wilting point and water holding capacity of the soil in the 0-30 cm depth of soil layer were 12.0, 3.2 and 8.8% respectively. The bulk density of the soil was 1.47 g/cc. The hybrid variety MSFH8 was sown in January 1995 with a spacing of 45 x 20 cm. A uniform dose of 50 kg P_2O5 and 30 kg K_2O per ha. was applied at the time of sowing. Nitrogen was applied in two equal splits, half at sowing and the remaining 30 days after sowing as per treatments. The gross and the net plot sizes were 21.60 and 15.66 m2. Water (5cm) was given to each treatment and the water was measured through a V notch. The number of irrigations received were 5, 7 and 9 with IWCPE ratios of 0.5, 0.75 and 1.0 respectively. Protein content' in the seed was estimated by multiplying the nitrogen content (%) in the seed with 6.25.

Scheduling irrigation at IW/CPE ratio of 1.0 recorded significantly higher plant (132.52 cm) and total dry matter (514.31 g/m^2) compared to the other ratios (Table 1). Application of 100 kg N/ha resulted in taller plants (130.68 cm) and maximum dry matter production (696.29 g/m^2) at harvest. Application of nitrogen with shorter irrigation intervals is mainly responsible for the higher plant vegetative growth as indicated by the plant height and dry matter production (Patel and Singh, 1981). Maximum plant height (143.43 cm) was recorded when irrigations were scheduled at IW/CPE ratio of 1.0 with the application of 100 kg N/ha followed by 1.0 ratio with 50 kg N/ha (136.43 cm) which were significantly superior to the rest of the interaction combinations. The dry matter production at harvest was maximum (675.38 g/m^2) with the application of 100 kg N/ha at IW/CPE ratio of 1.0 followed by 0.75 ratio (647.55 g/m^2). Scheduling irrigations at 1.0 ratio produced significantly more number of green leaves (10.8,) at harvest compared to other ratios. Application of 100 kg N/ha recorded highest number of green leaves (11.43) at harvest followed by 50 kg N/ha (10.74) and the differences were found to be significant. Highest number of green leaves (11.70) were produced with the application of 100 kg N/ha when irrigations were scheduled at IW/CPE ratio of 1.0 followed by 0.75 ratio (11.46) which were at par but significantly superior to the rest of interaction treatments. The effect of nitrogen was more pronounced in maintaining more number of green leaves at harvest compared to irrigation schedules.

Irrigations at short interval (1.0 ratio) resulted in increased diameter of earhead (13.52 cm) and higher test weight (45.30 g). Application

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of 100 kg N/ha also resulted in maximum diameter of earhead (14.11 cm) and test weight (45.49 h). Karami (1977) and Khargakharate and Nirwal (1991) also reported similar results. Application of 100 kg N/ha at shorter irrigation intervals recorded significantly larger earheads and maximum test weight. Availability of soil moisture and nitrogen application improved seed filling in sunflower leading to higher test weight.

Irrigation had no significant effect on oil content. However application of nitrogen affected oil content. Increase in the level of nitrogen decreased oil content. However interaction effects were found to be significant with higher oil content of 42.63 and 42.62% when irrigations were scheduled at IW/CPE ratio of 0.75 and 1.0, respectively when nitrogen was not applied. Lowest oil content (37.56%) was recorded with the application of 100 kg N/ha when irrigations were scheduled at IW/CPE ratio of 1.0. Kameswara Rao and Gangasaron (1991) and Leela Rani and Madanmohan Reddy (1994) also reported lower oil content with the application of nitrogen. Seed protein content was however influenced by both the factors and their interaction. Irrigations at shorter intervals increased the protein content (18.82 and 18.67% with 1.0 and 0.75 ratios respectively over longer irrigation interval. Application of higher doses of nitrogen boosted the seed protein content to a great extent over no nitrogen application. A combination of 100 kg N/ha with IW/CPE ratio of 1.0 resulted in maximum seed protein (21.59%).

Maximum seed yield 91993 kg/ha) was recorded when irrigations were scheduled at IW/CPE ratio of 1.0. The yield increase was 54 and 90% over 0.75 and 0.5 ratios. Application of 100 and 50 kg N/ha increased the seed yields significantly by 90 and 70% respectively over no nitrogen application. Highest seed yield (2329 kg/ha) was recorded when irrigations were scheduled at IW/CPE ratio of 1.0 with the application of 100 kg N/ha which was significantly superior to the rest of interaction effects. Increased number of green leaves at harvest, larger earheads and test weight with the application of higher doses of nitrogen in combination with frequent irrigation was mainly responsible for higher seed yield (Karami, 1977; Shaik Mohammad and Sagar, 1983 and Khargkharate and Nirwal, 1991).

Water use efficiency (WUE) based on seed yield was higher (4.59 kg/mm) when irrigations were scheduled at IW/CPE ratio of 0.75 which was significantly superior to the other ratios. It was mainly due to lower water requirements (350 mm) compared to 1.0 ratio (450 mm) and higher seed yield compared to 0.5 ratio. However application of nitrogen increased w.u.e. significantly with the maximum (5.67 kg/mm) with 100 kg N/ha. Interaction effects were also found to be significant with the maximum w.u.e. (6.31 kg/mm) at 0.75 IW/CPE ratio with 100 kg N/ha. It might be due to lower water requirements and higher nitrogen level resulting in the maximum seed yield.

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Table 1 : *Effect of irrigation and nitrogen on growth and yield of sunflower.*

Treatments	Plant height (cm)	No. of green leaves	Total dry-matter (g/m^2)	Head Diameter (cm)	Test weight (g)	Oil content	Seed protein content	Seed yield (kg/ha)	W.U.E (kg/mm)
Irrigation (IW/CPE ratio)									
0.5	115.00	10.37	411.65	11.88	38.64	40.45	17.24	1050	4.19
0.75	119.02	10.56	479.80	13.23	41.84	40.63	18.67	1611	4.59
1.0	132.52	10.87	514.31	13.52	45.30	40.27	18.82	1993	4.42
Nitrogen (kg/ha)									
0	109.76	9.64	368.86	11.05	37.49	42.53	14.05	992	2.79
50	126.10	10.74	410.61	13.47	42.79	40.73	19.39	1687	4.74
100	130.68	11.43	626.29	14.11	45.49	38.08	21.28	1975	5.67
CD (0.05)									
Main effects	1.86	0.18	1.98	0.93	1.07	0.56	0.53	33	0.09
Irrig x Nitrogen	3.23	0..30	3.43	1.61	1.85	0.97	0.92	57	0.17

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EFFECT OF INTERCROPPING SUNFLOWER WITH LEGUMES ON YIELD AND ECONOMICS

In Andhra Pradesh sunflower is grown in an area of 16.47 lakh hectares with a production of 0.66 lakh tonnes. Sunflower is a widely spaced crop and it offers opportunity for growing grain legumes as intercrops (Singh and Singh, 1977). Higher productivity and returns in intercropping system depends on the selection of compatible crops and their geometry (Shivaramu and Shivashankar, 1992). The information on Kharif sunflower intercropped with legume crops for Telangana region is not available. Hence, an experiment was conducted to identify suitable intercrop in sunflower and to find out extent of advantage by adopting intercropping system with different legume crops. Keeping this in view, four legume crops viz., pigeonpea (LRG 30), Cowpea (C-152), Soybean (MACS 201) and blackgram (LBG 20) were tried as intercrops in rainfed sunflower grown in different planting patterns.

A field experiment was conducted at College of Agriculture, Rajendranagar, Hyderabad in Kharif 1995. The soil of the field was sandy loam having a pH of 7.7, medium in available N (245 kg/ha), medium in available P_2O_5 (25 kg/ha) and high in available K_2O (449 kg/ha). The total precipitation received during crop growth period was 973.5 mm in 39 rainy days. The treatments included were two planting patterns of sunflower, sole cropping under normal (45 cm x 30 cm) and paired (30/60 cm x 30 cm) planting and intercropping of four legume crops pigeonpea cowpea, soybean and blackgram in normal and paired planting of sunflower. In addition to above treatments, sole crops of redgram, cowpea, soybean and blackgram were also included, thus constituting foruteen treatments tested in randomized block design in 3 replications. The crops were sown on July, 9, 1995. All the recommended crop management practices were followed as and when required. The plant population of legumes in intercropping treatments was half that of the sole cropping. Sunflower received 75 kg N, 40 kg P_2O_5 and 30 kg K_2O/ha. Total quantity of P_2O_5 and K_2O was applied as basal to sunflower, 50 per cent of N was aplied as basal and balance 50 per cent N was top dressed at 45 DAS. Recommended levels of N, P_2O5 and K_2O were applied as basal to sole legumes and 50 per cent of recommended levels of N, P_2O_5 and K_2O were applied as basal to sole legumes and 50 per cent of recommended levels of N, P_2O_5 and K_2O were applied as basal to legumes in intercropping systems as 50 per cent of sole legume populations were maintained. The total productivity was presented in terms of seed equivalent of sunflower after converting intercrop yield into sunflower based on market prices.

Significantly higher sunflower seed equivalent was obtained from sole pigeonpea. This was followed by sunflower (normal) + piegeonpea and sunflower (paired) + pigeonpea intercropping system (Table 1). This was due to better seed yield of sunflower and pigeonpea in intercropping because of their temporal complimentarity (Willey, 1979) coupled with higher market price of pigeonpea than other legume intercrops. Seed yield of sunflower was maximum in sunflowr (normal) + cowpea intercropping system which was due to increased yield attributing characters like number of filled seeds and seed yield per plant. Among the various sole crops piegeonpea gave higher seed yield (20.8 q/ha) and seed euivalent of sunflower (29.85) q/ha) as copious of rainfall received during later part of the crop growing stages resulted in increased flowering, pod formation and pod development. Very low

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yield of cowpea was observed in sole crop as well as in intercrop. This was mainly because of poor growth of cowpea coupled with less market price.

Economic evaluation in terms of gross and net returns showed that the sole Pigeonpea gave higher gross returns as well as net returns of Rs.31,200/ha and Rs.25,300/ha, respectively. Among the various intercropping systems, sunflower (normal) + pigeonpea followed by sunflower (paired) + pigeonpea gave higher gross anolnet monetary returns.

The benefit-cost ratio was higher in sole pigeonpea followed by sunflowr (normal) + Pigeionpea intercropping system. Thus growing sole Pgeonpea is recommended for higher monetary benefits where good amount of rainfall is received during later part of crop growth stage. However, in a normal rainfall year sunflower + Pigeonpea intercropping system could be more economical in terms of seed equivalent of sunflower and gross and net monetary returns.

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Table 1 : Effect of intercropping of sunflower with legume crops on seed yield, equivalent of sunflower and economics.

Treatments	Seed yield (q/ha)		Seed equivalent of sunflower (q/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit cost ratio
	Sunflower	Legume crops				
Normal Planting (45x30cm)						
Sole sunflower	8.05	-	8.05	8,412	2,581	0.44
Sunflower + Pigeonpea	7.15	9.80	21.24	22,201	14,724	1.97
Sunflower + Cowpea	8.47	1.80	9.80	10,249	2,915	0.40
Sunflower + Soybean	5.85	5.18	8.72	9,107	1,721	0.23
Sunflower + Blackgram	5.93	6.76	13.50	14,109	6,790	0.93
Paired planting (30/60x30cm)						
Sole sunflower	8.18	-	8.18	8,548	2,717	0.47
Sunflower + Pigeonpea	6.41	9.40	19.93	20,823	13,336	1.78
Sunflower + Cowpea	8.43	1.42	9.55	9,987	2,653	0.36
Sunflower + Soybean	5.80	7.07	9.72	10,161	2,775	0.38
Sunflower + Blackgram	5.48	8.65	14.43	15,079	7,760	1.06
Sole Pigeonpea	-	20.80	29.85	31,200	25,300	4.28
Sole Cowpea	-	5.20	3.98	4,160	-1,400	-0.25
Sole Soybean	-	11.98	6.65	6,948	1,587	0.30
Sole Blackgram	-	12.80	16.09	16,819	11,200	2.02
S.Ed. ±	0.96	-	0.80	276.48	48.25	0.05
CD (P=0.05)	2.02	-	1.70	580.90	300.96	0.20

Price of sunflower - Rs.1,045/q, Redgran - Rs.1,500/q, Cowpea - Rs.800/q, Soybean- Rs.580/q, Blackgran - Rs.1,314/q.

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CHEMICAL AND CULTURAL WEED CONTROL IN SOYBEAN

Herbicidal weed control becomes inevitable in crops grown in monsoon season on account of excessive growth of various weed species. In soybean, yield reductions to the extent of 30 to 77 per cent have been reported (Chandel and Saxena, 1988 and Tiwari and Khurchania, 1990) due to weed infestation particularly in early stages of growth. In the present study, herbicidal control of weeds in soybean was evaluated in comparison to hand weeding and weedy check.

A field experiment was conducted during rainy season of 1992 in a randomized block design with thirteen treatments (Table 1) replicated thrice at Reseaarch Farm, National Research Centre for Soybean, Indore. The soil was Typic Chromusterts (pH 7.86 and EC 0.14 ds/m) having 0.3% organic carbon, 11 kg/ha available phosphorus and 350 kg/ha available potassium. Soybean variety PK 472 was grown following recommended package of practices. The seed at the rate of 75kg/ha was sown on 18th July, 1992 and harvested on 3rd November, 1992. The observation on weed dry matter per m^2 was recorded after 6th weeks of sowing.

The data revealed that all the weed control treatments numerically lowered the total dry weight of weeds as compared to weedy ckeck. However, Pendimethalin 50 EC @ 1 kg a.i./ha as PPI did not differ significantly with weedy check and was at par with pre-emergence application of Metolachlor 50 EC @ 1 kg a.i./ha and Klass @ 1 kg a.i./ha, two hand weedings at 21 and 42 days after sowing (DAS), one dose at 25 DAS, postemergence application of Sethoxydim @ 1.5 kg a.i./ha and alachlor 10 G @ 2 kg a.i./ha.In case of Metolachlor and Klass, the number of sedges had major contribution to increase the total number of weeds, whereas these chemicals were equally effective as other treatments in controlling grasses and non-grasses. Except for two treatments referred above, the dry weight of sedges was not high and differences with weedy check were non-significant. The data also brought out that all the herbicides used were effective in controlling grassy weeds.

All the weed control treatments resulted in variations in yield attributes like branches per plant, pods per plant, seeds per pod and harvest index, but the differences were non-significant. The plant height was maximum in weedy check, and may be accounted for higher competition between weeds and soybean crop as compared to rest of the treatments.

Maximum seed yield (2800 kg/ha) was recorded when the sowing was done at narrow spacings of (22.5 cm) and the Alachlor 50 EC was used at half (1 a.i.kg/ha) the recommended dose, indicating the effectiveness of combining culturl and chemical control methods. The other treatments namely Fluchloralin @ 1kg a.i./ha (PPI), Clomozon @ 1kg a.i./ha (PE), Pedimethalin @ 1kg a.i./ha (PE), Metolachlor @ 1 kg a.i./ha (PE), two hand weedings at 3 and 6th weeks after sowing and alachlor 10G @ 2 kg a.i./ha yielded between 2679 kg/ha and 2512 kg/ha and were at par with best treatment. Except Klass @ 1 kg a.i./ha, rest of the treatments yielded numerically higher than control. The application of herbicide Klass @ 1 kg a.i./ha as preemegence was observed to be phytotoxic to soybean.

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The experimental results suggest that soybean planting at 22.5 cm with alachlor @ 1 kg a.i./ha (PE) was effective in controlling weeds as well as increasing productivity.

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Table 1. Weed dry weight, weed control efficiency and yield of soybean as influenced by different weed control treatments.

Treatment	Dose (kg a.i./ha)	Weed Dry weight (g/m^2)				Weed control efficiency (%)	plant height (cm)	Branches/ plant (No.)	Pods/ plant (No.)	Seeds/ pod (No.)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
		Sedges	Grasses	Non grasses	total								
Fluchloralin PPI	1	0.20	0.15	0.47	0.82	87.90	47.27	3.5	33.6	1.56	2679	3864	40.13
Metolachlor PE	1	2.80	0.00	0.53	3.33	50.88	52.97	3.6	36.1	1.79	2535	3514	41.92
Alachlor PE	2	0.27	0.00	0.22	0.49	92.77	49.53	3.7	41.7	1.72	2329	3835	37.78
Alachlor 10G PE	2	0.50	0.30	0.58	1.12	83.48	52.87	4.0	38.1	1.53	2512	3052	46.93
Klass PE	1	2.80	0.00	0.25	3.05	55.01	41.87	4.8	47.1	1.37	2133	2947	43.12
Clomozon PE	1	0.00	0.00	0.80	0.80	88.20	47.47	3.2	38.7	1.77	2559	3340	43.36
Pendimethalin PPI	1	2.73	0.83	0.56	4.12	39.23	49.70	3.9	35.7	1.43	2394	3191	44.17
Pendimethalin PE	1	0.53	0.00	0.25	0.78	88.49	47.70	3.4	35.2	1.59	2554	2940	46.36
Sethoxydim Post E	1.5	0.00	0.36	0.50	1.86	72.00	51.07	3.6	35.3	1.69	2462	3905	39.02
Soybean at 22.5 cm +Alachlor PE	1	0.60	0.00	0.23	0.83	87.75	47.53	3.4	35.2	1.68	2800	4088	42.98
One dose at 25 DAS		0.00	0.35	1.17	1.52	77.55	52.37	2.9	36.5	1.40	2459	3914	43.23
Two hand weedings		1.00	0.23	1.05	2.28	66.37	57.60	3.4	36.2	1.61	2524	3358	43.09
Weedy check		3.00	1.81	1.97	6.78	--	61.20	3.8	44.0	1.59	2345	3016	45.22
CD ($p = 0.05$)		NS	0.41	0.90	3.18	-	5.33	NS	NS	NS	304	NS	NS

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EFFECT OF INSECT AND DISEASE CONTROL MEASURES ON SOYBEAN (*Glycine max* (L.) Merrill) YIELD IN MADHYA PRADESH

Soybean, in India is attacked predominantly by about 2 dozen different insect species and about 10 different diseases. Effect of attack by individual insect and/or disease on yield of soybean has been well documented (Tachibana, 1971; Laviolette *et al.*, 1976; Lim, 1980; Thakur, 1985; Kundu and Trimohan, 1986; Singh *et al.*, 1991; Singh and Singh, 1992; Shukla, 1994). For harnessing the full yield potential, it is imperative to minimize the multiple-stress caused by insect-pests and disease complex prevailing in the region. Information on a consolidated assessment of impact of insect and disease control measures on soybean grain yield is meagre. This study was, therefore, undertaken to assess the effect of insect and disease control treatments on soybean grain yield, and to evaluate the economic feasibility of controlling these biotic stresses.

Field experiments were conducted during rainy seasons of 1993 and 1994 at the National Research Centre for Soybean, Indore, Madhya Pradesh, in randomized block design with four replications. Soybean variety "Punjab-1" was sown on 9th July in 1993 and on 25th June in 1994, in individual plots of 27 sq m size. The treatments were as follows:

T-1 (untreated check) : only water was sprayed to ensure similar microclimate as that in other treatments.

T-2 (disease control) : pre-sowing seed treatment with thiram 50 WP and carbendazim 50 WP @ 1.5 g + 1.5 g per kg seed, followed by sprays of carbendazim 50 WP @ 0.1% at 15 days after germination (DAS) and streptocyclin @ 200 ppm at 45 DAS.

T-3 (insect control) : soil application of phorate 10 G @ 10 kg/ha at sowing, followed by sprays of quinalphos 25 EC (0.05%) at 15 DAS, endosulfan 35 EC (0.07%) at 30 DAS and monocrotophos 36 SC (0.04%) at 45 DAS.

T-4 (diseased and insect control) : both T-2 and T-3 were applied separately to control diseases and insect-pests.

All other recommended agronomic practices like, fertilizer, weed control, intercultural operations etc. were uniformly followed in all the treatments. Net plot yield was taken at harvest maturity and converted to t/ha. Data were analyzed and pooled critical difference (CD) was calculated to compare the mean yield in different treatments, as proposed by Gogoi and Sandhu (1984).

During the course of study, the major disease and insect-pest complex comprised 6 diseases and 9 insect species. Although yields obtained in the year 1994 were low, due to early withdrawal of monsoon at critical seed-fill stage, but similar trend was observed with respect to disease and/or insect control treatments (Table 1). Maximum average yield (2.616 t/ha) was realised when both disease and insect control meassures were applied. Only disease control treatment (2.231 t/ha) did not record significantly higher yield than the untreated check (1.981 t/ha). This indicated that disease pressure on the crop was low to cause economic losses.

Insect control treatment on the other hand, gave significantly higher yield (2.516 t/ha) than disease control treatments and untreated check.

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Interestingly, this yield was at par with the yield obtained when both disease and insects were controlled together (T-4). It implied that insect-pest complex played important role in causing economic yield losses in soybean in this region. Compared to untreated check, insect + disease control, insect control, and disease control treatments, gave 32.33 %, 26.80 % and 12.50 % additional yields, respectively.

Economic returns and the cost benefit ratios under different treatments showed that an additional income of Rs. 2375 per ha was obtained when only diseases were controlled, Rs. 5083/ha when only insects were controlled and Rs. 6033/ha when both diseases and insects were controlled (Table 2). Taking into account the costs involved in insect and/or disease control treatments, the cost:benefit ratio was maximum (1:3.08) when only insects were controlled. It must be clearly conceived here that disease and insect control treatments applied in this study were aimed at minimizing these biotic stresses to maximum possible extent. In nature, incidence of different diseases and that of insects does not occure in comparaable intensities. Hence, all the treatments are not always essentially required. Under such circumstances, practically the cost involved in the treatments would not be as high as in the present study, and consequently, the benefit could still be higher.

Results of this study convey that insect and disease management in soybean need to be given high priority to harness full yield potential, and to enhance the productivity levels. Information on additional yields, realised by controlling insect-pests and disease complex (or yield losses, with respect to insect + disease control treatment) could also serve as a basis of developing multiple - species economic injury levels, as suggested by Hitchins *et al.* (1988).

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Table 1. Effect of controlling insect-pests and diseases on soybean yield.

Treatments	Grain Yield (t/ha)			Additional yield over T-1 (%)		
	1993	1994	Pooled	1993	1994	Pooled
T - 1	2.556	1.405	1.981	-	-	-
T - 2	2.884	1.576	2.231	12.83	12.17	12.50
T - 3	3.256	1.776	2.516	27.38	26.40	26.89
T - 4	3.361	1.871	2.616	31.49	33.17	32.33
Mean	3.014	1.657	2.336	23.90	23.91	23.91
S.Em.±	0.112	0.58	0.85			
LSD (P=0.05)	0.356	0.187	0.253			

Table 2. Economics of Insect-Pests and disease control in soybean

Treatments	Average grain yield (t/ha)	Cost of produce (Rs)	Additional yield over T-1 (t/ha)	Value of additional yield (Rs)	Cost of treatment (Rs/ha)	Net profit (Rs)	Cost: Benefit Ratio
T - 1	1.981	18820	-	-	-	18820	-
T - 2	2.231	21195	0.250	2375	1508	19687	1:1.57
T - 3	2.516	23902	0.535	5083	1648	22254	1:3.08
T - 4	2.616	24852	0.634	6033	3156	21696	1:1.91

Cost(Rs/ha): Soybean = Rs.9500/t, phorate = 400, quinalphos = 335, endosulfan = 261, monocrotophos = 202, thirum = 21, carbendazim (seed treatment) = 52, carbendazim (forliar spray) = 345, streptocyclin = 790, labour charges = 150.

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EFFECT OF HYDRATION - DEHYDRATION ON GROWTH AND YIELD IN SOYABEAN

Seed deterioration in soybean is a serious concern to the farmers of Andhra Pradesh, since the use of seeds with low vigour results in poor field performance of the crop. It is often observed that the seeds of one season can not be used for sowing in the next year due to quick loss of germinability. In such cases supply of quality seeds become one of the major constraints in soybean production. Seed deterioration can be slowed down through hydration - dehydration technique (Singh and Sudhakar, 1991). An attempt was made to assess the efficacy of different hydration-dehydration treatments to improve the field performance of soybean seed.

Soybean seeds with a germinability of 90 and 70 percent were obtained from RARS, Lam Farm, Acharya N.G. Ranga Agrcultural University. Half the quantity of seed with 90 percent germination (high vigour) was subjected to accelerated ageing at 95 +/- 1% relative humidity and 35°C temperature for 3-4 days till they attained 50 percent germinability (low vigour).

Seed with differential germinability were soaked twice their volume of water and dilute solutions of sodium chloride ($1x10^{-5}$M) P-hydroxy benzoic acid (1×10^{-3}M), tannic acid (2×10^{-5}M) for 1 hour subjected to moist sand conditioning - drying (absorbtion of moisture from moist sand for 24 hours) and moist sand conditioning - soaking - drying (absorbtion of moisture from moisture sand for 24 hours and soaking in water for 1 hour). Later, all treated seeds including control were dried (30°C) back to their original moisture content (8%). The seed material was sown immediately after the treatments in the *Kharif* season of 1991 and 1992, following factorial randomised block design with 21 treatments replicated thrice. The seeds were sown at a spacing of 30 cm x 10 cm in plot of size 3.5 m x 2.1 m. In each plot, five plants in a row were tagged and data on plant height were recorded at fortnightly interval. The plants were sampled at fortnightly interval to record leaf area. At maturity, data on yield components was also recorded.

Growth in terms of plant height and leafyness was affected by different levels of seed vigour in soybean. There was a gradual increase in plant height and leaf area index upto 75 days after emergence which decreased thereafter (Table 1). High vigour seeds recorded maximum plant heigh and leaf area index followed by medium and low vigour seeds. The degree of deterioration in seed showed a corresponding decrease in growth parameters. Roberts (1972a) reported that for every unit decrease in germination percentage there could be some decrease in crop growth rate and increase in plant to plant varation in growth rate. Among the seed treatments, p-hydroxy benzoic, tannic acid, MSC-S-D recorded significantly higher values of LAI (4.5 to 4.8) compared to untreated control (3.0). The beneficial effects of seed treatments on growth attributes were primarily due to continuation of initial benefits in subsequent growth stages (Karthiresan *et al* 1984). Types of seed and hydration-dehydration treatments influenced the leaf area, leaf area index, growth and yield.

Yield in crop plants is the ultimate expression of many yeild attributes which are dependent on each other. There was a significant decrease in the yield components with the decline in vigour and germinability of soybean seed (Table 1). The decrease in test weight due to loss of vigour

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was reported in soybean (Burries *et al* 1972).

Hydration-dehydration treatments in high, medium and low vigour seeds with p-hydroxy benzoic acid and tannic acid and MSC-S-D prior to sowing influenced the yield components and thereby yield compare to untreated control.

Though, Basu (1976) reported that the loss of productivity cannot be made up merely by increasing the seed rate of a deteriorated seed lot, hydration-dehydration treatments especially with chemicals like p-hydroxy benzoic acid (1×10^{-5}M) and tannic acid (2×10^{-5}M) would greatly help to overcome the problems of low seed yield in soybean.

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Table 1. Effect of Hydration-Dehydration on growth and yield in soybean (Pooled data of Kharif 1991 & 1992).

Treatments	Plant Height (cm) Days after emergence				Leaf area index Days after emergence				No. of Pods/ plant	Hundred seed weight(g)	Seed yield (t/ha)
	30	60	75	90	30	60	75	90			
Type of seeds											
High vigour	18	44	55	54	0.93	3.42	3.93	2.19	32	12.4	2.40
Medium vigour	18	43	54	53	0.83	3.03	3.69	2.15	29	12.0	2.20
Low vigour	16	42	53	52	0.81	2.88	3.58	2.25	28	11.85	2.10
CD(0.05)	0.6	0.6	0.6	0.5	0.06	0.06	0.06	0.06	1.2	0.06	0.06
Hydration-Dehydration (H)											
Control	13	35	46	46	0.63	2.38	2.87	1.76	23	9.95	1.65
Water	17	44	55	54	0.89	3.22	3.95	2.18	31	12.40	2.40
NaCl (1x10-3M)	16	42	54	54	0.86	3.06	3.81	2.22	30	11.55	2.30
Benzoic acid (1x10-5M)	17	45	58	56	0.90	3.30	3.18	2.30	32	12.50	2.55
Tannic acid(2x10-5M)	18	46	56	56	0.94	3.41	4.05	2.40	32	13.00	2.48
MSC-D (Moist sand Conditioning -Drying)	15	42	54	54	0.81	2.95	3.59	2.14	28	11.35	2.25
MSC-S-D (Moist sand conditioning-soaking-drying)	17	45	56	55	0 .93	3.30	3.90	2.25	31	12.80	2.35
CD (0.05)	0.9	1.2	0.9	0.9	0.09	0.09	0.09	0.09	1.9	0.09	0.09
HVS X H											
control	14	38	50	49	0.68	2.65	3.15	1.81	25	10.35	1.90
Water	17	43	55	54	0.95	3.52	4.04	2.14	33	12.55	2.50
NaCl	17	43	55	54	0.91	3.08	3.98	2.07	27	11.85	2.45
BA	18	45	56	55	1.02	3.68	4.20	2.31	34	12. 85	2.60
TA	18	45	56	55	0.99	3.62	3.99	2.36	37	12.85	2.60
MSC-D	16	46	54	53	0.92	3.27	3.87	2.07	31	11.65	2.35
MSC-S-D	19	46	57	56	1.06	3.79	4.13	2.45	34	13.65	2.65
MVS X H											
Control	13	35	46	45	0.61	2.47	2.86	1.63	23	9.90	1.70
Water	17	45	55	54	0.91	3.19	3.44	2.26	30	12.50	2.30
Nacl	16	43	54	54	0.81	2.89	3.71	2.66	29	11.50	2.20
BA	18	46	56	55	0.93	3.42	4.17	2.32	32	13.30	2.40
TA	17	44	56	56	0.88	3.25	3.19	2.27	31	13.00	2.50
MSC-D	16	43	54	55	0.77	2.95	3.31	2.12	29	11.30	2.20
MSC-S-D	17	44	55	54	0.85	3.16	3.85	2.25	30	12.30	2.30
LVS X H											
Control	13	39	44	43	0.57	2.02	2.96	2.35	21	9.67	1.54
Water	16	44	54	54	0.82	2.95	4.23	3.99	29	12.30	2.37
Nacl	16	42	53	53	0.85	2.19	4.07	3.69	29	11.36	2.27
BA	17	45	55	53	0.87	3.14	4.31	4.02	29	12.91	2.40
MSC-D	16	42	53	52	0.76	2.77	3.98	3.95	27	11.23	2.11
MSC-S-D	17	44	55	55	0.82	3.08	4.08	3.64	29	12.49	2.16
CD (0.05)	1.6	1.6	1.6	1.5	0.16	0.16	0.15	0.16	3.22	0.16	0.10

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EFFECT OF INORGANIC AND BIOFERTILIZERS (*AZOSPIRILIUM*) ON THE YIELD OF RAINFED NIGER

Niger crop (*Guizotia abysinica* L.) is extensively grown by tribals on marginal, sloppy, gravelly, stoney soils characterized by moisture retentivity and shallow depth in Satpura zone of Madhya Pradesh. Niger Oil is good for heart patients besides its industrial uses, while cake is a good poultry and cattle feed. Price hike in fertilizer deters the farmers from applying recommended dose of fertilizer. The prime need of today is to have a pollution free environment which is possible by utilizing the beneficial effects of soil microorganisims. As niger in general, is a poor man's crop, as such no attention has been paid to use of costly fertilizers. Use of biofertilizer also saves land and water from being polluted. Therefore efferts were made to study the individual and combined effects of chemical and *Azospirillum* (biofertilizer) on the yield and economics of rainfed niger.

A field experiment was conducted at JNKVV, Zonal Agricultural Research Station, Chhindwara on sandy clay soil having pH.7.4, organic carbon 0.60% with available P 12.5 and K 460 kg/ha in a Randomised Block Design with each treatment replicated 4 times. Six treatments- control, seed inoculation (20 g/kg), soil inoculation @ 2kg/ha, seed inoculation (20 g/kg) + 10 kgN/ha, soil inoculation @ 2 kg/ha + 10kg N/ha and 20 kg N + 20 kg P_2O_5/ha (recommended dose) were included. Generally, as farmers do not use fertilizers, P is not included in first five treatments. *Azospirillum* (biofertilizer) was used for seed and soil inoculation. The experiment was sown on 8th August in 1993 and 25th July in 1994. The variety used was otacmund. Country plough with *sarta* as fertilizer-cum-seed drill was used for sowing seed. Dry sand was mixed with seed (1:20 ratio) and culture (1:50 ratio) as per required quantity. The crop was harvested at maturity. Data on yield and yield attributing characters were collected.

Yield components and yield

The data presented in Table 1 indicated that the yield of niger was significantly affected by the use of *Azospirillum* either as seed or soil inoculation and nitrogen and phosphours applications. This also brought about an improvement in yield attributer of niger. The maximum plant height of 62.21 cm was obtained with soil inoculation and application of N at 10kg/ ha, while recommended dose of N and P application each at 20 kg/ha showed higher number of capital (19.28) and test weight (3.33 g) than other treatments. Slightly moderate effect of the culture was observed on yield attributing characters due to seed or soil inoculation over control.

The highest yield of 5.4 q/ha was obtained in the treatment with recommended dose of N and P followed by soil inoculation application of 10kg N ha (4.99 q/ha) against 3.61 q/ha in control. Seed inoculation with *Azospirillum* raised the yield by 8.58%, while soil inoculation enhanced the same by 15.51%. Maximum increase in yield was observed with full dose of N and P applications. Increase in yield of niger may be attributed to improvement in yield attributing characters due to biofertilizer inoculation and fertilizers. Increase in yield (1.5 q/ha) was noticed due to inoculation and fertilizers. Increase in yield (1.5q/ ha) was noticed dueto application of N and *Azotobacter* inoculation which further improved with N applied at 20 kg/ha (Anonymlous, 1995/

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96). Significantly higher yields were reported by Banger *et al.* (1992) and Sawarkar and Goydani (1995) in surgarcane and wheat crops, respectively.

Economics

Data presented in table 1 showed cost: benefit ratio (C:B) of 1:48.08 with seed inoculation as compared to soil inoculation (1:7.87). However the treatment of soil inoculation + 10 kg N/ha gave higher C:B ratioof 1:9.77 followed by oilseed inoculation (1:8.82) with same level of N application. The lowest C:B ratio of 2.52 was obtained with full N and P each applied at 20 kg/ha.

Therefore, soil inoculation at 2 kg/ha + N application at 10 kg/ha is advised for achieving higher yield of niger under rainfed conditions.

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Table 1. Effect of inorganic and biofertilizer (*Azospirillum*) on yield components and yield of rainfed niger.

Treatment	*Plant Height (cm)*			No. of Capitula/Plant			1000 Seed Wt. (g)			Seed Yield (g/ha)			Increase in Yield(%)	C:B ratio
	1993	1994	Mean	1993	1994	Mean	1993	1994	Mean	1993	1994	Mean		
1. Control	55.20	53.15	54.17	14.51	13.0	13.78	3.16	3.20	3.18	3.60	3.62	3.61		
2. Seed Ineoculation 20 g kg^{-1}	58.32	56.05	57.18	14.30	16.85	15.57	3.24	3.23	3.23	3.97	3.87	3.92	8.15	1:48.08
3. Soil Inoculation 2kg ha^{-1}	59.70	57.76	58.72	14.95	16.35	15.65	3.27	3.25	3.26	3.88	4.46	4.17	15.51	1:7.87
4. Seed Inoculation 20g kg^{-1}+ 10 kg N ha^{-1}	63.23	57.85	59.04	17.93	18.25	18.09	3.30	3.26	3.28	4.39	4.92	4.31	19.39	1:8.82
5. Soil Inoculation 2 kg ha^{-1}+ 10 kg N ha^{-1}	63.40	61.03	62.21	18.65	19.80	19.22	3.32	3.30	3.31	4.94	5.04	4.99	28.23	1:9.77
6. 20kg N ha^{-1} + 20 kg P_2O_5 ha^{-1}	62.80	53.30	61.05	19.22	19.35	19.28	3.42	3.24	3.33	5.94	4.87	5.40	49.58	1:2.52
C.D. (P=0.05)										0.57	0.32			

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EFFECT OF PHOSPHORUS ON NODULATION, CONCENTRATION AND BALANCE SHEET OF P IN SOYBEAN VARIETIES.

Cultivationof soybean (*Glycine max.* L.merrill) is being popularized owing to its profitability in Chhattisgarh region. Among the various factors of production, varieties and phosphorus application assume greater significance. The present experiment was conducted to find out the suitable level of phosphorus to soybean varieties for maximizing nodulation and P uptake and also to explore whether, phosphorus application to the crop could be avilable for the succeeding crop (Banwarlal *et al.*, 1994).

A field experiment was conducted during rainy season of 1995 at Indira Gandhi Krishi Vishwavidyalaya, Raipur. The treatments comprised 3 levels of phosphorus [30, 60 and 90 kg P_2O_5/ha] as main plots and 5 varieties [Gaurav (JS72-44), PK 472, JS 335, JS 80-21 and JS 75-46] as subplots, replicated thrice in split-plot design. The experimental plot had clayey (vertisols) soil, neutral in reaction (pH 7.2), low in available nitrogen (275 kg N/ha), and low to medium in available phosphorus (24.0.6 kg kg P_2O_5/ha). The crop was sown on 28 June and was fertilized with uniform doses of 30 kg/ha each of nitrogen and potasium. The crop was harvested from 2 to 12 October, 1995 depending upon the maturity period.

Nodule number and their dry weight increased significantly with increasing level of phosphorus, but the differences between 60 and 90 kg P_2O_5/ha was not significant at both the stages. Banwarilal *et al.*, (1994) and Mohd. Abbas *et al.*, (1994) have made similar observation. The phosphorus concentration in plant was not affected due to phosphorus application, but increased with increasing levels of phosphorus at all the growth stages (Table 1). Availability of phosphorus in soil at harvesting stage and uptake of phosphorus by soybean crop increased significantly with increasing levels of phosphorus, but the difference between 60 to 90 kg phosphorus level was not significant, Banwarilal *et al.*, (1994) for lentil, Mohd. Abbas et al. (1994) soybean aand Ved singh *et al*, (1994) for groundnut also indicated that uptake of phosphorus increased with increasing level of phosphorus. Regarding per cent increase or decrease in available soil phosphorus over initial values, maximum depletion (11.3%) has been recorded under 30 kg P_2O_5/ha and it decreased with 60 kg P_2O_5/ha and even a net gain of 5.6 per cent in available soil phosphorus was recorded under higher level of phosphorus, Singh and Faroda (1985) also observed the negative (under lower level) and positive (under higher level) values of available phosphorus after the harvest of *Kharif* pulses. The number of days taken to maturity was not affected by phosphorus application.

Nodule number and phosphorus concentration in plant were not affected due to varieties at all the growth stages. The maximum nodule number and phosphorus concentration were recorded in JS 335 variety followed by PK 472. However, significantly higer nodule dry weight was recorded in JS335 and PK 472 which were at par, over rest of the varieties at both the stages except at 35 DAS where JS 75-46 also produced same nodule dry weight as in case of above two varieties. Maximum depletion has been recorded in JS 75-46 because of the less dry matter accumulation (straw yield) and nodulation which resulted in more extraction of soil phosphorus. As regards uptake of phosphorus it was observed that variety JS 80-21 remaining at par with JS 335 and PK 472 significantly higher phosphorus from soil than Gaurav and JS 75-46 Varieties.

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Table : Nodulation , phosphorus concentration and uptake of P by soybean varieties as influenced by phosphorus.

Trestt.	Nodule number/ plant DAS		Nodule dry wt. (mg) DAS		P-concentration in plant(%) DAS			Available phosphorus at Harvest (kg/ha)	% increase or decrease Over initial values of P	Uptake of P (kg/ha)
	35	75	35	75	35	75	Harv.			
Phosphorus (kg P_2O_5)										
30	25.2	36.2	120	215	0.63	0.42	0.23	21.3	-11.3	15.14
60	30.4	48.0	141	246	0.67	0.45	0.25	22.9	-4.8	18.57
90	36.6	47.4	156	259	0.68	0.47	0.27	25.4	5.6	19.06
SEm ±	1.8	1.6	4.1	4.8	0.03	0.02	0.02	0.7	-	0.62
CD 5%	7.1	6.3	16.1	18.8	NS	NS	NS	2.7	-	2.44
Variety										
Gaurav	27.7	38.3	128	215	0.69	0.53	0.23	23.3	- 3.0	17.03
PK 472	35.0	47.7	143	255	0.62	0.46	0.26	23.4	- 2.7	18.14
JS 335	36.3	49.0	155	266	0.69	0.46	0.30	23.7	- 1.3	19.71
JS80-21	26.0	36.0	126	239	0.68	0.46	0.25	23.0	- 4.4	20.26
JS75-46	28.6	40.0	144	224	0.61	0.41	0.23	22.6	- 6.2	12.82
SEm ±	4.1	4.3	5.4	6.2	0.04	0.03	0.03	0.5	-	0.87
CD (5%)	NS	NS	15.7	18.1	NS	NS	NS	NS	-	2.54

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EFFECT OF IRRIGATION AND FERTILITY ON PRODUCTIVITY, ECONOMICS AND ENERGY OUT-PUT OF LINSEED (*Linum usitatissimum* L.)CULTIVARS

Linseed (*Linum usitatissimum* L.) is an important oilseed crop extensively grown in Madhya Pradesh. Different agronomical practices share the major portion of total operational and non-operational energy inputs consumed in its cultivation. Both non-renewable and renewable sources of energy contribute a lot to the productivity of this crop. Consumption of energy has been increasing in steady rate for improving the productivity, but energy use efficincy is declining consistently. Though climate, soil and management factors and renewable energy sources greatly influence the crop production, non-renewable sources of energy which are exhaustible, dominate the major share of total energy inputs cosumed in farming system.

Hence, a field experiment was conducted on linseed during winter season, 1989-90 in clay loam soil at the farm of college of Agricultural Engineering, Jabalpur (M.P.) to determine the energestics of linseed cultivation. The soil of the experimental field was netural (pH 7.2) in reaction having 278 kg N, 21 kg P_2O_5 and 360 kg K_2O ha^{-1}. The treatments consissted of 3 irrigation levels viz; no irrigation, one irrigation at 30 days after sowing (DAS) and two irrigations at (30 and 60 DAS) in main plots, three fertilizer levels viz. no fertilizer, 309 kg N + 15 kg P_2O_5 + 10 kg K_2O ha^{-1} and 60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} in sub plots and three varieties viz. JLS-1 T-397 and JL-23 in sub- sub plots. They were tested in a split-plot design with three replications. Sowing was done on November, 12 and October, 22 in 1989 and 1990 respectively, using a seed rate of 30 kg ha^{-1} in rows 30 cm apart. All the fertilizers were applied at the time of sowing as per treatments. Harvesting was done on March, 14 and 6 in the two consecutive years. Cost of cultivation and economic value of the produce were worked out on the basis of the existing market rates of the inputs and output. The computation of energy input and output was made on the basis of energy equivalance as suggested by Mittal and Dhawan (1988).

Two irrigations given at 30 and 60 DAS significantly produced higher seed yield than one irrigation given at 30 DAS and no irrigation during both the years (Table 1). Only one irrigation at 30 DAS was found superior to no irrigation. Application of 60 kg N + 30 kg P_2O_5 + 10 kg K_2O ha^{-1} P_2O_5 + 10 kg K_2O ha^{-1} and no fertilizer during both the years. These results are in close conformity of Rao, (1982) and Tomar *et al.* (1985). Amongst the varieties, JL-23 out yielded consistently in both the years, but differences were not significant in first year. The varieties JLS-1 and T-397 did not significantly differ in seed yield, though the latter gave higher yield.

Linseed crop irrigated twice at 30 and 60 DAS offered higher net returns as compared to those obtained under one irrigation and no irrigation. Cost of production for per unit produce under two irrigations was Rs. 4.20 kg^{-1} against Rs. 4.70 kg^{-1} with one irrigation and Rs. 5.10 kg^{-1} with no irrigation. Thus, two irrigations resulted in maximum benifit-cost ratio (2.50) as compared to 2.25 and 2.10 under one irrigation and no irrigation, respectively. This indicates that increased cost of cultivation due to irrigations helped to increase proportionately the seed yields. Application of 60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} gave the highest net return and benifit-cost ratio with the lowest cost of production, as compared to 30 kg N + 15 kg P_2O_5 + 10 kg K_2O

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ha^{-1} and control. The variety JL-23 provided the highest net return and benifit-cost ratio with the lowest cost of production than T-397 and JLS-1.

Increased number of irrigations required more quantum of total energy input (Table 2). Two irrigations given at 20 and 60 DAS required total energy input of 6586 MJ ha^{-1} which was significantly higher by 14.5 and 29.1 % than one irrigation and no irrigation treatments, respectively. The energy output was also higher with two irrigations treatment since output energy is directly related to seed yield. Energy output was minimum (12187 MJ ha^{-1}) which increased by 34.0 and 14.6% due to two and one irrigation treatments, respectively. Similarly increasing levels of fertility as control (no fertilizer), 30 kg N + 15 kg P_2O_5 + 10 kg K_2O ha^{-1} (F1) and 60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} (F2) also required greater energy input and gave more energy output. The energy input (3357 MJ ha^{-1}) were minimum with control which increased by 57.4 and 114.7, and 48.6 and 110.4% due to F1 and F2 fertility levels, respectively. The energy input requirement for all the three varieties was equal, but energy output varied significantly among them. The variety JLS-1 had the lowest energy output (13431 MJ ha^{-1}). The varieties T-397 and JL-23 showed 4.58 and 12.39 % higher energy output, respectively. The energy ratio was maximum (2.60) with no irrigation which slightly declined due to two (2.50) and one (2.45) irrigation treatments. This indicates that increase in irrigation was energy efficient. No fertilizer had the maximum energy ratio (2.60) among the fertility levels, but the value declined inconsistently to 2.48 and 2.57 due to F1 and F2 fertility levels, respectively. The results reveal that application of fertilizer as under F2 was energy efficient. The energy indices in T-397 (2.50) and JLS-23 (2.71) varieties were higher than JLS-1 (2.39). This indicates that JL-23 and T-397 varieties were promising for increasing the nergy output.

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Table.1 *Effect of irrigation and fertility levels on different varieties of linseed*

Treatment	Seed yield(kg ha^{-1})			Cost of cultivation (Rs ha^{-1})	Net return (Rs ha^{-1})	Benifit-cost Ratio
	1989-90	1990-91	Mean			
Irrigations at						
No irrigation	559	418	487	2475	2694	2.10
30 DAS	620	497	559	2625	3288	2.25
30 + 60 DAS	718	591	655	2775	4148	2.50
CD (P = 0.05)	80	16	-	-	-	-
Fertility level						
($N + P_2O_5 + K_2O$ **kg** ha^{-1})						
No fettilizer	461	291	375	2345	1642	1.69
30 + 15 + 10	632	482	557	2629	3259	2.23
60 + 30 + 15	815	733	791	2901	5485	2.90
CD (P = 0.05)	85	20	-	-	-	-
Varieties						
JSL-1	606	467	537	2625	3056	2.11
T-397	634	490	562	2625	3280	2.24
JL-23	658	550	604	2625	3758	2.37
CD (P = 0.05)	NS	17	-	-	-	-

NS- Not significant

Table 2. *Energy budgeting of irrigation, fertility level and varieties in linseed cultivation*

Treatment	Energy input	energy out put (MJ ha^{-1})	energy ratio (MJ ha^{-1})
Irrigation at			
No irrigation	4672	12187	2.60
30 DAS	5629	13968	2.50
30 + 60 DAS	6586	16370	2.45
Fertility levels			
($N + P_2O_5 + K_2O$ **kg** ha^{-1})			
No fertilizer	3577	9370	2.60
30 + 20 + 10	5629	13927	2.48
60 + 30 + 20	7680	19775	2.57
Verities			
JLS - 1	5629	13431	2.39
T-397	5629	14047	2.50
JL-23	5629	15096	2.71

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NEW RECORD OF TWO COCCINELLIDS AS PREDATORS OF BUD FLY, Dasyneura Lini Barnes IN LINSEED.

While monitoring of linseed fields during February - March 1994, the corp was found to be seen with two coccinellids, *Coccinella septempunctata* Linn. and *Menochilus sexmaculatus* Fabr. The gurb and adult stages of both predators were observed to prey upon the fulfed maggots of bud fly, *Dasyneura lini*, crawling on the plant twigs, mostly in morning hours just before the pupation. It was also noticed during the blooming season in 1995 that the adult stages of the coccinellids were able to pick-up the maggots from the soil surface. The feeding property of both predators was 10-15 per cent in all possibilities. Their feeding efficiency was maximum in the morning hours between 8.00 to 11.00 a.m., because the maggots of bud fly remain on the plant twigs due to dew and come down for pupation by crawling on twigs, and do not fall directlyto the ground. The maximum population of both coccinellids was noticed in the middle of February, which was 5.33 grubs with 8.67 adults of *C. septempunctata* whereas 3.67 grubs and 5.67 adults per plant in case of *M. sexmaculatus*. The predators were found more active in aphid infested crop. A study of literature reveals that these coccinellids have not been reported earlier, as the predators of maggots of bud fly, however, Deshmukh *et al.* (1992) listed *C. septempunctata* L. as a natural enemy, but did not specify its host.

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As Editor of the Journal of Oilseeds Research for volumes 13 and 14, I enjoyed my work and did my best to maintain and improve the functionality and quality. The credit for this would mainly go to the authors, but for whose hard work and contributions, we would not have been able to run the Journal. The referees have played their part excellantly and helped me through their suggestions and critical comments in keeping up certain standards for the Journal. I earnestly thank them for sparing their time and expertise. I also thank all the executive committee members (1996-97) for reposing confidence in me and nominating me as Editor. I am grateful to all members of ISOR who are the real back bone of this organisation. I also thank all the Editorial Board members and others involved in the editorial job, like correspondence, proof reading, DTP and printing etc. I once again thank one and all who have whole heartedly helped and cooperated with me in publishing this Journal.

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